This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

University of Virginia Library
I 19.8: 917/PT.1
ADOC Minerals yearbook / prepared b
RX 001 878 187

2.

I 19.8:1917
Pt. 1.

DEPARTMENT OF THE INTERIOR
JOHN BARTON PAYNE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

MINERAL RESOURCES
OF THE
UNITED STATES
1917

H. D. McCASKEY
Geologist in Charge, Division of Mineral Resources

PART I—METALS

H. D. McCASKEY, Geologist in Charge

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

CONTENTS.

[The dates of publication of the separate chapters are given in parentheses.]

Page.

The economic limits to domestic independence in minerals, by George Otis Smith (Dec. 28, 1918) 1A
International control of minerals, by C. K. Leith (Dec. 31, 1918) 7A
Mineral production of the United States, by H. D. McCaskey and M. B. Clark (June 28, 1920) 17A
Prefatory note to the reports on gold, silver, copper, lead, and zinc, by H. D. McCaskey 77A
Bauxite and aluminum, by J. M. Hill (June 21, 1918) 1
Platinum and allied metals, by J. M. Hill (June 21, 1918) 11
Arsenic, by J. B. Umpleby (June 19, 1918) 23
Bismuth, by J. B. Umpleby (June 19, 1918) 29
Selenium, by J. B. Umpleby (June 19, 1918) 33
Tellurium, by J. B. Umpleby (June 19, 1918) 35
Chromite, by J. S. Diller (Aug. 8, 1918) 37
Cadmium, by C. E. Siebenthal (July 12, 1918) 49
Gold, silver, copper, lead, and zinc in the Eastern States, by J. M. Hill (July 29, 1918) 55
Tin, by Adolph Knopf (Sept. 16, 1918) 63
Silver, copper, lead, and zinc in the Central States, by J. P. Dunlop and B. S. Butler (Oct. 24, 1918) 73
Gold, silver, copper, and lead in Alaska, by G. C. Martin (Nov. 21, 1918) 131
Magnesium, by R. W. Stone (Dec. 11, 1918) 147
Gold, silver, copper, and lead in South Dakota by C. W. Henderson (Jan. 27, 1919) 153
Gold, silver, and copper in Wyoming, by C. W. Henderson (Jan. 27, 1919) 161
Gold, silver, copper, lead, and zinc in Utah, by V. C. Heikes (Feb. 8, 1919) 167
Gold, silver, copper, lead, and zinc in California, by C. G. Yale (Feb. 18, 1919) 203
Gold, silver, copper, and lead in Oregon, by C. G. Yale (Feb. 18, 1919) 243
Gold, silver, copper, lead, and zinc in Nevada, by V. C. Heikes (Feb. 18, 1919) 253
Secondary metals, by J. P. Dunlop (Feb. 19, 1919) 299
Gold, silver, copper, lead, and zinc in Montana, by V. C. Heikes (Feb. 21, 1919) 331
Quicksilver, by F. L. Ransome, with a bibliography by I. P. Evans (Mar. 18, 1919) 367
Gold, silver, copper, lead, and zinc in Idaho, by C. N. Gerry (Apr. 3, 1919) 457
Gold, silver, copper, lead, and zinc in Washington, by C. N. Gerry (Apr. 3, 1919) 493
Gold, silver, copper, lead, and zinc in Arizona, by V. C. Heikes (Apr. 1, 1919) 509
Iron ore, pig iron, and steel, by E. F. Burchard (Apr. 28, 1919) 557
Gold and silver (general report), by H. D. McCaskey and J. P. Dunlop (May 9, 1919) 605
Antimony, by E. S. Bastin (May 13, 1919) 653
Manganese and manganiferous ores, by D. F. Hewett (Oct. 31, 1919) 665
Gold, silver, copper, lead, and zinc in New Mexico, by C. W. Henderson (Nov. 8, 1919) 697

Page.
Gold, silver, copper, lead, and zinc in Texas, by C. W. Henderson (Nov. 8, 1919). 721
Copper (general report), by B. S. Butler (Mar. 13, 1920) 723
Gold, silver, copper, lead, and zinc in Colorado, by C. W. Henderson (Mar. 1, 1920) 797
Zinc (general report), by C. E. Siebenthal (Apr. 6, 1920) 855
Lead (general report), by C. E. Siebenthal (May 8, 1920) 881
Cobalt, by F. L. Hess (Aug. 31, 1920) 899
Molybdenum, by F. L. Hess (Aug. 31, 1920) 907
Nickel, by F. L. Hess (Aug. 31, 1920) 917
Titanium, by F. L. Hess (Aug. 31, 1920) 929
Tungsten, by F. L. Hess (Aug. 31, 1920) 931
Radium, uranium, and vanadium, by F. L. Hess (Aug. 31, 1920) 955
Index 961

ILLUSTRATIONS.

Page.
PLATE I. Map showing world's output of tin in 1916, in short tons 70
II. Map showing the location of those quicksilver deposits of the world, some output from which is on record 386
III. Map showing the location of the known quicksilver deposits of the United States 388
IV. Curves showing production and value of gold and silver in the world, 1860–1917 612
V. Diagram showing imports of antimony and average prices of ordinary grades of antimony metal in New York market, by months, 1914 to 1918, inclusive 654
VI. Map of world showing location of principal copper-producing centers. 728
VII. Curves showing weekly average prices of zinc at St. Louis and London and of zinc concentrates at Joplin; also weekly production of zinc concentrates in the Joplin region, 1914–1917 878
VIII. Average weekly price of lead at New York and London in 1914–1917. 896
FIGURE A. Curves showing the value of the mineral production of the United States, 1880–1917 34A
1. Map of North America showing known deposits of chromic iron ore. 39
2. Average yearly prices, in cents per pound, of Straits tin in New York, and world's output of tin, in metric tons, 1900–1917 68
3. Diagram showing quantity and value of quicksilver produced in the United States from 1850 to 1917, inclusive 369
4. Diagram showing variations of monthly average market quotations for domestic quicksilver at San Francisco from 1913 to 1917, inclusive 377
5. Diagram showing prices of quicksilver in London, New York, and San Francisco in 1917 380
6. Curves showing annual production of iron ore, pig iron, and steel in the United States, 1870 to 1917 559
7. Source and destination of iron ore imported into the United States in 1917 579
8. Curve showing prices of basic pig iron at blast furnaces in Mahoning and Shenango valleys, Ohio and western Pennsylvania, 1912 to 1917, by months 589

Page.
FIGURE 9. Curve showing production of coke and anthracite pig iron in the United States, 1912–1917, by months 592
10. Curves showing production and value of gold and silver and price per fine ounce of silver in the United States, 1871–1917 609
11. Diagram showing stocks of metallic antimony in bonded warehouse at end of each month in 1917 and 1918 654
12. Diagram showing contract prices of ferromanganese, spiegeleisen, and manganese ore, 1912–1917 681
13. Curves showing the principal features of the copper industry, 1907–1918 727
14. Production of copper by countries, 1913 and 1917 728
15. Relative production, consumption, imports, and exports of copper by the principal copper producing and consuming countries in 1913 729
16. Labor employed and copper produced in the different classes of copper mines, 1916 and 1917 734
17. Diagram showing prices of molybdenum ore and of molybdenum in ferromolybdenum, 1917 908
18. Graph showing prices for tungsten ore carrying 60 per cent of WO_3 and of tungsten in ferrotungsten carrying 72 to 78 per cent of tungsten 935

INSERT.

Mineral products of the United States, 1908–1917 .... In pocket.

MINERAL RESOURCES OF THE UNITED STATES, 1917—PART I.

THE ECONOMIC LIMITS TO DOMESTIC INDEPENDENCE IN MINERALS.

By GEORGE OTIS SMITH.

The war demands placed upon the United States created many new problems in connection with the supply of raw materials. Not only were former sources of supply cut off by the war's interference with commerce, but the large industrial expansion due to the world's larger need of American manufactured products caused in turn increased consumption of raw materials; the net result was an unprecedented and a too largely unexpected call upon the basal industries of the country—agriculture, forestry, and mining.

Already the United States had become more nearly independent than any other industrial nation in the production of minerals; our output in 1913 was 36 per cent of the total for the world and included even larger percentages of the mineral fuels and copper, aluminum, zinc, and sulphur. Yet there were on the other side of the Nation's ledger notable deficiencies in tin, platinum, nickel, manganese, chrome, potash, and nitrates, and the domestic supply of some of these minerals continues to be hopelessly inadequate. To meet the war demand for every mineral raw material was the larger task set before the mineral industry, and the degree of success attained and its cost are the basal facts in any inquiry as to the economic limits that must be recognized in developing the domestic supply.[1]

The conditions presented in the four years of war have been novel and have changed from month to month. Yet in no sense have these changing conditions been outside the realm of economic law. Premises previously unthought of because they involved facts outside former experience, such as destruction of cargo ships or shortage of freight cars, have formed the basis for action incredible in its novelty yet so necessary that the term "war times" was used to express the excuse for every act seemingly in violation of both business sense and economic law. In fact, however, both economic law and business sense were being applied to new problems and in new ways in obtaining the raw materials for a nation's expanded industry.

---

[1] The writer neither overlooks nor minimizes the international phase of the utilization of mineral resources, but because of the many-sided nature of the whole subject, the arrangement has been made for Prof. Leith to present the broader outlook in the paper which follows. It is hoped in this way to suggest more of the facts and principles that must be kept in mind by one who approaches the solution of this economic problem.

Under these special conditions of supply and demand some minerals have taken on new values—indeed, certainty of supply has had larger significance than price. These new values may persist for varying periods, but for some products they must be recognized as only temporary.

It is enlightening, however, to note how large a family of inventions and improvisations can be credited to necessity, and how these substitutes born in time of need develop into lively competitors with the older commodities. Thus, certain potassium salts may never recover the industrial fields that were temporarily (it was thought) given over to the equivalent salts of sodium, and sintered dolomite already competes with magnesite, even though a domestic supply of magnesite is now assured and the imported magnesite may be again available as shipping conditions become normal.

The peace readjustment of the mineral industry requires immediate consideration, involving as it does the future of war-born infant industries but first of all the recalculation of the country's needs. It may be only suggested here that the real issue is to what extent it is of national benefit that this or that new industry should be continued, and that national benefit is to be measured in terms of the premise that industry is the basis of social welfare, not an end unto itself or an opportunity for profit to the few. So it becomes a debatable economic question how much influence can be properly exercised on the natural course of commercial evolution. American experience has shown that some industries soon outgrow the need of governmental fostering but that others never grow up. An all-important element in the problem is whether the product meets an essential need of the country.

In speaking of the expected war demands for raw materials the present writer earlier made the statement that "the mineralogic curiosity of one decade may become the valuable ore of the next." As the years of war have passed many illustrations of this truth have come to the notice of the Survey's investigators. Perhaps no better example can be cited than that of the Leucite Hills, in Wyoming. The Government geologist who was classifying the public coal lands in that vicinity desired to add to our knowledge of this unique occurrence of interesting rock types, and before the Survey could publish his scientific contribution the world potash situation gave potential economic value to his field study. His quantitative estimates of possibly available potash content are now the incentive to large expenditures in working out extraction processes on a commercial scale, and quarry sites have been selected where he mapped this peculiar rock. The latest example of an unforeseen use of scientific data is the connection that has recently been developed between the shipping program and the Survey's investigations of the quality of water. These studies of the surface waters of the United States were begun years ago, and their basis has been geologic as well as chemical. The practical usefulness of the results has, of course, been realized from the start, in connection with steam making and other industrial uses of river water, but recently it was found that with a supply of brass tubes sufficient only for the condensers of the naval and merchant vessels under construction, steel tubes must be substituted wherever possible in other condenser installations, and the extent of this substitution, as ordered by the War Industries Board, was conditioned by the quality-of-water data furnished by the Geological Survey.

The war program, with its reaction upon industry, has opened the eyes of many to old facts. Mineral raw materials have won a recognition based upon the new realization of their value. De Launay's recent and apt characterization of coal and iron as the two "grand seigneurs" of the mineral world[1] is in strong contrast with the ancient idea of nobility among metals. The new measure of value is usefulness.

Economic geology is useful geology—the theoretical science applied to meet the material needs of man. These human needs as presented in the last four years have demanded a specialized type of geology—the application of geology in terms of commerce. Geology to be most useful in these days of world problems must take the world view of values, and we find ourselves working in commercial geology—that is, geology applied in terms of commerce. The world is the field of commerce, and the requirements of commercial geology are simply that the geologic relations of a Nevada ore deposit, for example, must be observed with an eye trained to see far beyond the Basin range; the geologist needs to compare the quality and quantity of the unmined ore here with similar facts of nature that give value to the ores in other districts, as in Peru or Burma. Whether the investigator is called a geologist, mining engineer, or economist, his vision must take in not simply the ore minerals as they have been deposited, segregated, or enriched by the processes of nature, but also the smelted ore and the refined metal on their way to the markets of the world, where they can serve mankind. Thus to broaden and extend the investigator's view is not to commercialize his science; it is rather to make geology more useful, and in that way to give the science a higher rank.

Geology must needs continue to furnish the basal facts, but the geologist has a call to go further than he has gone heretofore in the interpretation of his facts—not simply by translating his technical words into the language of the market place, but, more than that, by showing the relation of geology to national life.[2]

In terms of commercial geology, therefore, ore deposits take on competitive relationships, and in terms of national interest there must be a determination of relative worth. The practical question concerns not simply the quantity of metal present in the ore but the quantity that can be won to the profit of mankind. First of all, then, in fixing the economic limits to the utilization of domestic mineral deposits, comes the balancing of cost of production with the value of the product. This requirement, which holds good in any business undertakings, however small, is none the less operative in an industry viewed in its national aspect. Economic profit is attained only by reducing cost or increasing value until the margin appears on the right side of the account.

---

[1] France—Allemagne, p. 225, 1917.

[2] The series of interesting papers issued by the U. S. National Museum (Bull. 102) represents a timely effort in this direction. In these papers Messrs. Gilbert and Pogue have interpreted mineral resources as related to public interest.

Into the cost of production enter the items of transportation, investment, and labor. An industrial leader like Mr. Schwab[1] appreciates the "handicap of distance," although with a sportsman-like spirit he and other industrial leaders regard this handicap as simply another incentive to American ingenuity, not as a plea for preferential freight rates. The transportation factor has played a noteworthy part in every large production enterprise in the United States, where commonly mine and market are separated by hundreds if not thousands of miles.

Improvement in transportation, whether interstate or international, tends to the equalization of opportunity: the peoples of the world are brought closer together. Artificial rates, however, in either interstate or international commerce will impose burdens rather than confer benefits, and we can not afford to throw back to the era of rebates. Therefore the facts of transportation must be written into the statement of production costs; the geologist and the engineer must from the start be geographers, for distance can not be eliminated from any commercial problem. The place factor enters so largely into the determination of value of mineral raw materials that many a promoter would gladly have the scientific investigator close his eyes to the facts regarding the accessibility of the deposit under examination. Yet the transportation cost is too often the cause of financial disaster, even when the geologic and other engineering facts have been correctly determined and are favorable to success.

Investment and labor costs come less under the purview of the geologic engineer in his study of mineral resources, yet the power element is one that touches both of these items and is not to be overlooked by any student of industrial problems. It becomes more and more evident that the use of power, either steam or water, will become the deciding factor in American industry. The statistics of man power cited by Butler[2] furnish the most convincing arguments as to the stability of our copper industry and its ability to dominate the world markets. The community of interest between some of the largest mining and power corporations is therefore to be regarded as a natural development along economic lines—not as an artifice in restraint of trade. Whether cheap power is made available for mine use by private initiative or by public control, the result is the same—cheap raw materials for other industries.

During the war period the value of raw materials was in large part due to the emergency demand, and the experience should leave its realization of the exigency element in the determination of value. Under war conditions no one questions the great advantage of domestic independence in raw materials, and then adequate supply rather than low price is all-desirable. Nearness of source of raw materials is advantageous at other times, but the amount that can then be added to the value on that account is less easily determined. The purchasing agent of a large manufacturing plant may favor the near-by to the distant source of raw material and the domestic to the foreign producer as a matter of assurance that there will be no interruption to "keeping the works running." Yet the spirit of cost accounting leads usually to the cheapest market. Again it happens that when a productive industry so contributes to some larger business or group of industries as to be absolutely essential to their continuance this key industry takes on a larger significance than its size suggests.

---

[1] American problems of reconstruction, p. 143, 1918.

[2] Butler, B. S., Copper: U. S. Geol. Survey Mineral Resources, 1917, pt. 1, pp. —— (in preparation).

In the consideration of any domestic industry the factor of home consumption must not be overlooked; indeed, home consumption is more directly connected with national welfare than exports. Our high per capita consumption of copper, for instance, means more to the Nation than our exportable surplus of the same metal, the true value of which is indirect through the means it furnishes for trade or exchange for imports of other commodities for our own consumption. A nation that robs its domestic consumers so as to have an exportable surplus or to sell that surplus at a price below cost will be copying a German blunder in economics. Increased consumption of metals and mineral fuels means expansion of all industries, which in turn should mean a larger home market for all the things that go with a higher standard of living.

The mineral control act of 1918 furnishes a too long delayed expression of the emergency value of mineral independence. The exigencies of war revealed many deficiencies in industrial preparedness, and although over one-third of the world output in essential minerals was credited to the United States at the beginning of the war period, the largest part of the raw materials found to be inadequately supplied included minerals and their derivatives. Interruption to the importation of a relatively few ores brought immediate realization of the industrial advantages of a domestic supply, and the coincident shortage in rail transportation showed that the disadvantage of an international long haul differs only in degree from that of too long an interstate haul. The premium that industry can afford to pay for the assurance of an uninterrupted supply of raw material provides the answer to this question of the emergency value of either national or local independence.

The proper valuation of national independence in raw materials therefore requires a careful weighing of the emergency factor, which introduces the insurance idea, as well as an estimating of future possibilities of lower costs as the industry develops. The incidental or the ultimate advantage may be so large as not to be seen by those who take too close a view of cost accounting or are shortsighted in their outlook on the Nation's business. The old contradiction of penny-wise and pound-foolish holds true to-day in matters of cents and dollars.

In every business there are elements of value that do not appear on the cost sheets. The war record of American business will not be complete except as it includes the story of those producers who kept up their output regardless of the losses involved—a type of patriotism not spectacular but exceedingly helpful. So, too, in time of peace there may be conditions under which, viewed in the larger way, it pays to do business at a loss.

A composite diagram of either current output or future reserves of the essential minerals for the countries of the world would show so large a centralization in North America as to suggest that here is a group of nature-favored nations. This strategic advantage expresses itself in the well-recognized large degree of self-sufficiency of the United States, so that the question of economic limits to domestic independence concerns a relatively small number of minerals and makes our problem quite different from that in other and less favored nations. However, whether the debatable list includes only chromite, manganese, pyrite, and potash or is much longer, clear analysis of the economic problem is needed, for cost keeping on a national scale is the only safeguard against a loss which is real even though not at once apparent.

Whether wisest utilization of mineral resources means full utilization is debatable, and every student of natural resources realizes that the time of utilization is often an element in the degree of wisdom shown. It is not necessarily prodigal wastefulness that only the richest ore is mined when a new district is discovered; creation of transportation facilities, construction of smelters and mills, and general advance in technology are the intermediate steps between bonanza exploitation and the highly organized operation of low-grade deposits. Utah had a long history as a mining State and its contributions to the world's wealth were large before Bingham started a new epoch in copper mining. So, too, the reworking of dumps and of tailings ponds furnishes illustrations of the complete utilization that is evolved in these changing conditions, and the appreciation of this truth should warn us against too hasty, off-hand determination of the economic limitations placed by nature upon mining development. By the very nature of things many successful mining ventures are at the start unprofitable, and many ore deposits can be fully developed only through actual mining operation. In a national sense it may prove that "nothing venture, nothing have."

The largest degree of national usefulness will be won from our mineral resources only through the highest industrial efficiency, which is in turn secured by engineering advance and the linking up of mechanical power and man power. This means to the end is typically American, but too much emphasis can not be put upon the importance of governmental action that is constructive in its cooperation with industry. While, unfortunately, public regulation seems to start usually with measures that are wholly restrictive in effect, because too often abuse of privilege has led to the legislative action, yet regulatory measures can be truly promotive, as has been shown in the recent cooperation of business and the Government. Public interest and private interest in the long run are less antagonistic than either the captain of industry or the public servant has suspected. It is true that the measure of economic worth must be the welfare of the individual, the community, and the people of the Nation, and not the dollar of profit to the corporation or the State, yet only a successful industry can be made to serve both owner and workman and the public as well. If the product is not actually worth its whole cost, no camouflage of bounty or tax exemption or import duty will long conceal the inherent weakness of the industry. The basic importance of the raw material resources to the country makes it a prime public duty of citizens generally to know the facts regarding the mineral industry, and to ascertain these facts the intensive study of our own resources is not enough: we must also acquire a comprehension of what minerals other countries contain to supplement what we have at home.

ume, wer
turbanc
ing, ir

INTERNATIONAL CONTROL OF MINERALS.

By C. K. Leith.[1]

WORLD MOVEMENT OF MINERALS.

The annual world production of minerals approximates 1,700,000,000 tons, over 90 per cent of which consists of coal and iron. Of this amount about two-thirds is used within the countries where the minerals are produced and one-third is shipped to other countries. The mineral production of the United States amounts to about one-third of the total.

In the discussion of mineral resources in their international aspects we are concerned primarily with the 33 per cent of the mineral output which moves between countries. It may be assumed that the consumption within the countries of origin is a matter of national rather than international concern.

One of the several interesting facts in this world movement of minerals is that the movement of most of them shows a rather remarkable concentration. For instance, manganese moves from three principal sources and converges at four or five consuming centers. Chromite moves from two principal sources; tungsten also from two. Even for certain commodities which are widely distributed and move in large amounts the concentration of movement is rather marked—for instance, the world movement of coal is controlled by the United States, England, and Germany. In other words, although the world movement of mineral commodities is widespread and exhibits many complex features, most of the individual minerals follow two or three salient lines of movement. This means in general that for each mineral there are certain sources of limited geographic extent, which, because of location, grade, relation to transportation, cost—in short, all the factors that enter into availability—are drawn upon heavily for the world's chief demands. The convergence of these materials toward a few consuming centers indicates generally concentration of coal production necessary to smelting, high development of manufacturing, large per capita use, concentration of facilities, strong financial control, and, not least, a large element of enterprise which has taken advantage of more or less favorable conditions.

Another significant fact which emphasizes the interdependence of nations and the importance of international considerations is that no country is entirely self-sustaining in its mineral requirements.

---

[1] Mineral adviser of War Industries and Shipping boards.

MOVEMENT OF MINERALS UNDER PRE-WAR CONDITIONS OF INTERNATIONAL TRADE.

If the world pre-war movement of minerals is considered broadly, it may be regarded as conforming essentially to normal trade conditions of supply and demand. There have been barriers to overcome, such as tariffs and trade controls and monopolies of various kinds, but these barriers have not prevented the major movements between the best sources of supply and the principal consuming centers. These movements may be regarded as a more or less spontaneous internationalization of mineral resources by private enterprise. The aim of free trade or unrestricted commerce was equality of trade opportunities, but such conditions of unrestricted competition tended to concentrate trade in the hands of the strongest interests and to prevent equality of opportunity.

The efforts made to promote or hinder international mineral movement by tariffs, bonuses, embargoes, subsidies, transport control, patents, Government management, financial pressure, and other means have been incited mainly by national or imperial self-interest and have thus been to some extent inimical to an internationalization based on the principle of the greatest good to the greatest number. It may be supposed that in any effort to attain supernational or international control, motives and measures based on national self-interest of the sort here mentioned will continue to play an important part. The question to be determined is the extent to which national interest can and will be subordinated to international interest.

CHANGES BROUGHT ABOUT BY THE WAR.

The war wrought fundamental changes in the world movement of minerals. The character and distribution of the demands changed. Customary sources of supply were cut off. Financial disturbances and ship shortage profoundly modified the nature, distribution, and extent of the world movement. Our domestic mineral industry was abruptly brought to a realization of its vital relations with international trade. To illustrate, the large movement of manganese from India and Russia to the United States was abruptly stopped, and we had to develop a source of supply in Brazil. The stoppage of pyrite importations from Spain as a means of saving ships required the development of pyrite and sulphur supplies in the United States. The export of oil from the United States to European countries was greatly stimulated, and the export to other countries was correspondingly decreased. The world movements of coal were vitally affected, principally by the limitation of the coal shipments from England and the United States to South America and the concentration of shipments to European countries. The closing of German coal supplies to near-by countries had far-reaching consequences. The cutting off of the German potash left the world for the time being almost unsupplied with this vital fertilizing ingredient. The Chilean nitrates, on which the world had relied for fertilizer, were diverted almost exclusively to the manufacture of powder. The total annual imports of mineral commodities into the United States were reduced by 1,200,000 tons. Our exports, though they continued in large vol-a, were mainly concentrated in Europe. The story of these dis- rbances in the world movement of minerals, though highly interest- ng, is too long to be told here.

INTERNATIONAL CONTROL AS A WAR MEASURE.

Out of these sweeping and rapid changes in the world movement of mineral commodities there arose, partly as cause and partly as effect, international agreements for the allocation of minerals, as a means of insuring the proper proportions of supplies to the different countries for the most effective prosecution of the war. Inter-Allied purchasing committees in London and in Paris found it necessary to make an inter-Allied allocation of the output of Chilean nitrate, because the sum of the demands exceeded the total supply by a considerable fraction, and to agree on distribution and price of the world's supplies of tin, tungsten, and platinum. For many other commodities agreements of various sorts were made. For instance, the United States entered into an agreement with England and France for the purchase of iron ore and molybdenum from Scandinavia to keep it out of Germany. The United States and England agreed as to supplying Canada with ferromanganese. New problems of world allocation came up almost daily.

POSSIBILITY OF POST-WAR INTERNATIONAL CONTROL.

We now face the immediate and pressing question whether the centralized international control required by the war shall be retained or extended as a means of furthering the aims of a league of nations. When such a league was first proposed emphasis was placed mainly on political and military considerations. It now seems to be recognized that these are so closely interlocked with economic considerations that any league of nations, to be effective as a means of minimizing future international discord, must make provision for some degree of international or supernational control of business. Recent statements by officials of Great Britain and France seem to indicate a definite purpose to urge such control.

Some of the reasons which have been urged for the international control of the movements of minerals are as follows:

1. To insure equitable distribution of certain minerals, such as tungsten, vanadium, platinum, and gold, of which there may be a world shortage.
2. To mitigate a world shortage of ships by international allocation of ship space, which would entail limitations on the movement of minerals.
3. To prevent nations which are more advantageously situated in regard to finance, location, and general control of trade from monopolizing the business in any commodity at the expense of other nations—in other words, to insure equality of opportunity in regard to basic raw materials. The control of many mineral commodities now approaches national monopoly.
4. To reach some agreement as to division of markets for commodities such as iron, steel, and coal, which are available in so great abundance that several of the larger nations have considerable ex-

portable surplus, in order to prevent international difficulties due to unrestricted competition.

5. To maintain equilibrium of price.

6. To insure common and equitable contribution of supplies for rehabilitation of the devastated countries.

7. To serve as a means of disciplining any nation that will not conform to any code or control established by a league of nations. To many this has been a dominant consideration.

8. In general to prevent economic friction that might vitiate any world political agreements.

9. To replace the crude and cumbersome arrangements for international control through complex treaties and tariffs by a more centralized system.

The foregoing is merely a list of suggestions that have been made; it is not a unit statement of the requirements of the situation.

SPECIFIC PLANS OF INTERNATIONAL CONTROL OF MINERALS.

The various schemes proposed to meet these requirements center fundamentally about allocation of supplies.

There seem to be two main lines of approach to this problem. One leads to equality of economic opportunity through means expressed as follows by the League of Free Nations Association of New York:

> (*a*) No state shall accord to one neighbor privileges not accorded to others—this principle to apply to the purchase of raw material as well as to access to markets.
>
> (*b*) States exercising authority in non self-governing territories shall not exercise that power as a means of securing a privileged economic position for their own nationals; economic opportunity in such territories shall be open to all peoples on equal terms, the peoples of nations possessing no such territories being in the same position economically as those that possess great subject empires. Investments and concessions in backward countries should be placed under international control.
>
> (*c*) Goods and persons of the citizens of all states should be transported on equal terms on international rivers, canals, straits, or railroads.
>
> (*d*) Landlocked states must be guaranteed access to the sea on equal terms both by equality of treatment on communications running through other states, and by the use of seaports.

The other main line of approach to the problem leads to definite international allocation of raw materials as a means of preventing the strong nations from crowding out the weak, an inequity which would be possible under even ideal arrangements for insuring equal economic opportunities. More specifically it is proposed that the exportable surplus of selected minerals from the countries that enter into a league of nations shall be distributed as may be mutually agreed. This proposal means presumably continuance of Government control of international trade through licenses and ships. It means a curbing of private initiative and a sacrifice of the self-interest of the stronger in favor of the weaker.

The purpose of this paper is to discuss some of the specific relations of this arrangement to the mineral industry of the United States, that we may weigh the advantages and disadvantages of international control.

POSITION OF THE UNITED STATES IN REGARD TO INTERNATIONAL CONTROL OF MINERALS.

The United States is more nearly self-sustaining in regard to mineral commodities as a whole than any other country on the globe. The following statement summarizes qualitatively our position:

1. Minerals of which there is an adequate supply or exportable surplus in the United States:
    - A. Minerals of which our exportable surplus dominates the world situation:
        - Copper.
        - Petroleum.
    - B. Minerals of which our exportable surplus constitutes an important but not a dominant factor in the world trade:
        - Sulphur.
        - Phosphates.
        - Silver.
        - Iron and steel.
        - Coal.
        - Cement.
        - Uranium and radium.
    - C. Minerals of which our exportable surplus is not an important factor in world trade. Small amounts of most of these minerals have been and will doubtless continue to be imported because of special grades, backhaul, or cheaper sources of foreign supply, but these imports are for the most part incidental:
        - Lead.
        - Zinc.
        - Aluminum and bauxite.
        - Gold.
        - Tungsten.
        - Molybdenum.
        - Asphalt and bitumen.
        - Pyrite.
        - Barite.
        - Fluorspar.
        - Building stone (except Italian marble).
        - Cadmium.
        - Gypsum.
        - Lime.
        - Tripoli and diatomaceous earth.
        - Mineral paints (except umber, sienna, and ocher from France and Spain).
        - Pumice.
        - Garnet.
        - Salt (except special classes).
        - Talc.
        - Arsenic.
        - Bismuth.
        - Bromine.
        - Artificial abrasives, corundum, and emery (except Naxos emery).
        - Fuller's earth.
        - Mercury.
2. Minerals for which the United States demand must continue to be met by imports:
    - A. Minerals for which the United States must depend almost entirely on other countries:
        - Tin.
        - Nickel.
        - Platinum and metals of the platinum group.

2. Minerals for which the United States demand must continue to be met by imports—Continued.
    - B. Minerals for which the United States will depend on foreign sources for a considerable fraction of the supply:
        - Antimony.
        - Vanadium.
        - Zirconium.
        - Mica.
        - Monazite.
        - Graphite.
        - Asbestos.
        - Ball clay and kaolin.
        - Chalk.
        - Cobalt.
        - Naxos emery.
        - Grinding pebbles.
3. Minerals normally imported into the United States which in future can be largely produced from domestic sources if it seems desirable:
    - A. The following minerals were mainly imported before the war, but under war conditions the domestic resources have been developed to such an extent that the United States can become self-sustaining if desirable, though at so great a cost that a protective tariff will be necessary if these industries are to survive:
        - Nitrates (except potassium nitrates).
        - Potash.
        - Manganese.
        - Chromite.
        - Magnesite.

No attempt will be made here to present the detailed figures on which the above generalizations are based. In view of the present disturbance in production and consumption, any judgment as to future demands or available surplus must take into account several factors which can not be accurately measured, such as financial control in foreign countries, possible tariffs, and foreign competition. For this reason the above statement should be regarded as only tentative, though it is the result of a rather exhaustive study of conditions in relation to the world control of shipping. The classes named overlap to some extent, and it is to be expected that some of the commodities placed in one class may in the near future be transferred to another.

GENERAL CONCLUSIONS AS TO THE INTERNATIONAL CONTROL OF MINERALS FROM THE STANDPOINT OF THE UNITED STATES.

1. It is clear that a league of nations offers but little advantage as a means of insuring adequate supplies for the United States, and that the limitations on the distribution of exportable mineral supplies would probably weigh more heavily on the United States than on any other country. The few minerals for which the United States is dependent on foreign countries are offset by so many in which we have a dominance of supply and our financial position is so strong that it appears certain that the United States does not need the aid of a league of nations to insure adequate supplies even of these few minerals. In short, in this respect our entrance into a league of nations would not be based on self-interest. We would sacrifice to some extent an independent and dominant position. In our dealings with other nations this fact should give weight to whatever emphasis the United States may wish to put on the desirability of international

control of minerals. At the same time it imposes a hard task on the United States to arouse the mineral interests to the support of a measure that involves so much self-sacrifice. The value of our annual potential exportable surplus of minerals approximates a billion dollars; that of our necessary mineral imports about $175,000,000. Our active allies, Great Britain, France, and Italy, together have a maximum annual exportable surplus worth perhaps $325,000,000, and their necessary imports amount to $265,000,000.

2. It seems clear that our effort to make this country entirely self-sustaining in regard to raw materials, which has been especially marked during the war, will need to be modified if we are to adapt ourselves to conditions of international control. Although we may be able to become self-sustaining in respect to essential commodities like manganese, chromite, and potash, by so doing we are cutting off the export market of other countries where these commodities exist in such quantities and grades that they would be, under conditions of free trade, our principal sources of supply. By drawing on such sources we not only get a cheaper and higher grade of product, but we develop a return market for the products in respect to which our natural advantages entitle us to a share in the export trade. The potash situation will illustrate the problem. The war cut off German supplies. We made every possible effort to meet the deficiency. Prices rose tenfold. Now, are we to continue this effort at high cost? Our instinctive answer is, Yes. But suppose at the peace table it is mutually agreed that for the welfare of France and Spain we should absorb a certain part of their output, or even that we should take German potash as an indirect way of collecting indemnity? This question is put for the purpose of making the problem concrete, and no answer is attempted here, though I venture to suggest that the practicable course will be found to lie between the two extreme alternatives.

If all countries take the stand that they must be self-sustaining in regard to natural resources, they can accomplish their purpose only by high artificial barriers to offset inequalities in the factors which determine the availability of the several commodities, with the result that the world movement of raw materials will be greatly lessened. Instead of free circulation of essential basic commodities vitalizing any world agreement there will be a series of compartments in which trade is maintained at different levels, under different pressures and conditions—a situation difficult to maintain and inimical to world agreements based on mutual concessions. It is clear that if each of the States of the United States should adopt the principle of making the State self-sustaining in minerals so far as possible, the result would be to increase largely the chances of interstate friction and to lower efficiency in the United States as a whole.

3. Following President Wilson, the League of Free Nations Association, before quoted, states: "Equality of economic opportunity does not mean the abolition of all tariffs or the abolition of the right of self-governing states to determine whether free trade or protection is to their best interests." If the view expressed in conclusion 2 is correct, it follows that the United States, as a member of a league of nations, would not be free to impose tariffs dictated by national self-interest beyond such minor duties as might tend to equalize the

labor element of cost of production. Also, when we remember the remarkable degree to which many of the leading mineral commodities are geographically concentrated, it is clear that a tariff on any particular commodity will usually affect mainly some one or two foreign nations—a result which does not accord with the principle that a state shall not give to one neighbor privileges that it withholds from others.

More might be said for a temporary tariff designed to let down easily, for example, the manganese, chromite, and potash industries, which face large losses because of overdevelopment to meet war needs. The Mineral Act perhaps might be used for this purpose. If this principle were adopted for a few minerals, however, it probably would soon be extended to others and into more general nonmineral fields, thereby presenting a problem of enormous difficulty.

In passing it may be noted that as long as shipping is inadequate, as it may be for some years, high and slowly declining freight rates may serve much the same purpose as a tariff for low-priced commodities of much bulk, like manganese, though not for high-priced commodities like tungsten.

Something might also be said for tariffs intended to insure the smelting of ores and their conversion to usable forms within the country of origin, thus reducing the tonnage to be transported and supporting the largest industry within the country; but it must be remembered that the distribution of coal resources and centers of production marks certain world centers of smelting and manufacturing, which are entitled by natural advantage to an unhampered movement of raw materials from other countries.

The question of protective tariffs is becoming acute at present, owing to the release of the restrictions imposed by the War Trade Board as a means of saving ships.

4. The interests of conservation clearly call for an international viewpoint in the handling of our mineral resources. The deposits of most minerals are so highly concentrated in their distribution and general availability that the principal sources for the world are in comparatively few places. When all factors of conservation are taken into account, including labor and efficient use of the product, it would seem that the minerals should be drawn from these natural sources of supply. To illustrate, the chromite and manganese deposits of the United States are relatively small and of low grade as compared with other sources of supply. Insistence on the use of the domestic material would mean early exhaustion of local supplies, lowered efficiency in use, and higher cost. As cost includes not only the intrinsic value of a product but items for labor and transportation, it appears that the use of these domestic materials means a higher expenditure of human effort than is necessary.

There is perhaps as much need of specializing in mineral output as there is of specializing in manufacturing. The thought that every country on the globe should be self-sustaining in regard to mineral supplies is of somewhat the same order as the thought that every family should produce all its own raw materials rather than take advantage of the more favorable conditions existing elsewhere and so specialize in human effort. If for a certain amount of capital and labor we can produce copper more cheaply than any other country and thus dominate the world's markets, it is not economy to divert this capital and labor to the production of ores of manganese or chromite, which because of natural conditions can be produced much more cheaply elsewhere.

5. Extension of international control of minerals seems to offer possibilities of loss and gain—loss through a considerable sacrifice of national trade and a narrowing of the field for private initiative in trade; gain through the possibility of attaining certain ends which are attainable only by international agreement, such as an allocation of supplies which will be to the advantage of the greater number of nations rather than to the advantage of the few that are strong enough to dominate the situation and which will in general prevent economic friction from endangering a league of nations based on political and policing considerations.

In a world governed by good will the effective internationalization of trade might well be gained by leaving trade unrestricted. In proportion as the actual condition may depart from this ideal condition, some sort of international agreement as to control seems justified. Such control would by no means eliminate international rivalries and jealousies; it would transfer them to the international governing body. The duties of such a body would be onerous and perplexing. It might even be supposed that nationalistic aspirations might be so strenuously presented and so firmly backed by national steps in the way of embargoes and protective tariffs that the international control would amount to little. But it may be further supposed that a league of nations whose members enter into it voluntarily and with mutual good faith might control the situation sufficiently to bring recalcitrant members into line. The questions thus suggested are difficult to answer.

6. It is sometimes argued that any attempt to control the movement of raw materials, for whatever purpose, defeats itself because it leads to the automatic development in the restricted area of increased exploration, new sources of supply, substitutions, etc. Restriction unquestionably has this effect, but nevertheless such measures are expensive makeshifts and offset the effects of limitation only in part, as is clearly proved by the experiences of the war.

7. The purpose of this paper is primarily to state the problem of international control of minerals, rather than to present an argument for it. Such control entails difficulties which are especially burdensome on the United States and which at present may be insuperable. The interests of conservation clearly require international control. Moreover, the lesson of the war points to the necessity of overhauling old international understandings and machinery, even though such a task would encounter great difficulties, not the least of which lie in the persistence of human habits and inertia. Whether the time has come to establish a league of nations with economic control can be determined only by our individual and collective answers to the question whether we are willing to make the necessary economic sacrifices, individually and nationally, in the interest of world harmony. The mineral industry should fully understand that with international control efforts to promote export will need to be modified and curtailed; that expansion of our trade in many lines will mean equivalent loss of trade to other nations; that the almost

universal conception that expansion of foreign trade is a meritorious aim and end in itself, without regard to its effect on other countries, will need revision. It is necessary only to cite the present movement to create great export associations under the Webb Act to show that present tendencies for definite action do not take into account the possible conflict of such action with the economic requirements of a league of nations.

8. Whatever action may be taken in regard to international control, it is clear that the war has brought the United States into such world relations that it has become imperative for us to study and understand the world mineral situation much more comprehensively than before, in the interest not only of intelligent management of our own industries but of far-sighted handling of international relations. When the European war began we found our mineral industries vitally affected by international developments which we only partly understood. Government mineral organizations, as well as those outside the Government, had given relatively little attention to foreign mineral resources and markets. Information and statistics were scattered and incomplete. Under the stress of war the Government, especially the Geological Survey, the Bureau of Mines, and the several war boards, found it necessary to use extraordinary efforts to obtain even elementary information on the international features of mineral trade. Much progress has been made, but only a start. I would like to make a plea for definite recognition of the necessity of a systematic study of the world's mineral resources from the world's standpoint to supplement the studies made of the domestic resources, both by the mineral industry itself and by governmental and other agencies. A plan is under way to transfer the special mineral activities of the war boards to the Department of the Interior. This will throw additional burdens on the Bureau of Mines and the Geological Survey. It is equally clear that organizations like the American Institute of Mining Engineers and our technical publications have the same reason for extending their current surveys of mineral conditions to cover the world.

MINERAL PRODUCTION OF THE UNITED STATES.

INTRODUCTION.

By H. D. McCaskey.

SCOPE OF REPORT.

The two parts of the report Mineral Resources of the United States (Part I, Metals, and Part II, Nonmetals), of which this chapter forms the introduction and summary, constitute the final official record of the mineral production of the United States for the year 1917. The statistical work on minerals during this war year was in general carried on in greater detail, on a basis of greater frequency, and with greater expedition than in any previous year, in order to supply the Government and the public with a part of the economic information required for successful military operations. The information collected was placed immediately and informally at the disposal of the war boards and the military branches of the Government, and much of it was promptly made public through the newspapers and the technical press. The expansion of the informational service on minerals with little or no increase either in funds or in personnel was accomplished by more arduous work and longer hours, and by the abandonment, for the time being, of some classes of Geological Survey work that were not of war utility. It has resulted, also, in delaying the preparation of a number of the chapters of Mineral Resources. These chapters were, however, published in separate form as fast as completed, many of them months or even a year in advance of the assembled report.

Mineral Resources for 1917 contains the statistics of production in the United States, the imports and exports for that year and for several preceding years, and the records of important new developments during 1917. The reader in search of full information in regard to a particular mineral industry is advised to consult also the volumes of Mineral Resources for previous years, in which many details not repeated in later reports will be found. For statistics carried forward, however, the reader should consult the latest volume, as it contains any revision made, not only of the reports for the years preceding but also of the reports published separately in advance of the volume. Each volume is a supplement to all that have preceded. Special features of an industry are discussed more fully in some years than in others. The volumes issued during the past decade and containing particularly full reviews of the several mineral industries are listed below. Figures of production and value of each mineral since 1880, by years, are given in the summary of mineral production for 1915.

Mineral Resources volumes, 1908–1917, which contain particularly full reviews of various industries.

Mineral.	Year.	Special features.
METALLIC.		
Aluminum	1914	Bibliography.
Antimony	1916	Do.
	1917	Full report.
Arsenic	1914	Do.
	1915	Bibliography.
Bauxite	1914	Do.
	1917	List of users.
Bismuth	1914	Full report.
	1915	Bibliography.
Cadmium	1908	Full report.
Chromic iron ore	1914	Bibliography.
	1916	Sectional drawings; additional bibliography.
	1917	Map of North America showing location of known deposits of chromic iron ore; list of mine owners.
Copper	1915	Map of United States showing location of copper-producing districts and reduction plants (pocket).
	1917	Maps; plates; foreign data.
Gold, silver, copper, lead, and zinc (mines reports):		
Alaska	1915	Gold production since 1880, by years and producing districts.
	1917	Metal production since 1880, by years.
Arizona	1914	Bibliography of Survey publications.
	1917	List of reduction mills, by counties.
California	1912	Do.
Central States	1914	Historical sketch of lead and zinc mining in upper Mississippi Valley region.
	1917	Bibliography of Survey publications.
Colorado	1911	Flow sheet of Leadville ores.
	1912	List of reduction mills, by counties; bibliography of Survey publications.
Eastern States	1912	Bibliography of Survey publications.
	1914	Historical review of gold production of southern Appalachian States since 1799; additional bibliography.
Idaho	1911	List of reduction mills, by counties.
	1913	Ore sold or treated, number of producers, and metal output of Coeur d'Alene region since beginning of mining in 1884, by years.
	1914	Metal production of State since beginning of mining in 1863, by 10-year periods; metal production of Blaine (Alturas) County since 1880, by years; gold and silver production of Boise County since 1863, by years; gold and silver production of Owyhee County since 1863, by years; bibliography of Survey publications.
Montana	1911	List of reduction mills, by counties.
	1913	Metal production of Silver Bow County since 1882, by years.
	1914	Bibliography of Survey publications.
Nevada	1911	List of reduction mills, by counties.
	1912	Zinc-lead ore dressing at Goodsprings, with flow sheet of mill.
	1914	Bibliography of Survey publications.
New Mexico	1912	List of reduction mills, by counties; bibliography of Survey publications.
Oregon	1912	List of reduction mills, by counties.
	1913	Bibliography of Survey publications.
South Dakota	1914	Gold and silver production since 1876, by years; bibliography.
	1917	List of reduction mills, by counties.
Texas	1912	List of reduction mills, by counties; bibliography of Survey publications.
	1914	Metal production since 1885, by years.

Mineral Resources volumes, 1908–1917, which contain particularly full reviews of various industries—Continued.

Mineral.	Year.	Special features.
METALLIC—continued.		
Gold, silver, copper, lead, and zinc (mines reports)—Continued.		
Utah	1911	List of reduction mills, by counties; flow sheet of Park City ore.
	1913	Ore sold or treated, number of mines producing, and metal output of State since 1865, by years; of Beaver County since 1860, by years; of Tintic district since beginning of mining in 1869, by years; of West Mountain (or Bingham) district since 1865, by years; of Park City mining region since 1870, by years.
	1914	Ore and metal production of American Fork district, 1870–1900, by 10-year periods, and 1901–1914, by years; of Big and Little Cottonwood mining districts since 1867; bibliography of Survey publications.
Washington	1911	List of reduction mills, by counties.
	1913	Ore sold or treated, number of mines producing, and metal output since beginning of mining in 1860, by years.
	1914	Bibliography of Survey publications.
Wyoming	1914	Metal production since 1842, by years.
	1916	Ore and metal production of Albany County since 1868; of Carbon County since 1898, by years; of Hartville district, Platte County, since 1882.
	1917	List of reduction mills, by counties.
Iron	1908	Maps showing distribution of ore and location of blast furnaces (pocket).
	1909	Map showing distribution of Lake Superior iron ore (pocket).
	1911	Iron ore reserves of Michigan, with map, by C. K. Leith; notes on prospecting.
	1915	Beneficiation of Lake ores.
	1916	Essential features of a deposit; bibliography.
Lead	1915	Bibliography (in chapter on zinc).
Manganese and manganiferous ores.	1917	Full report with bibliography.
Nickel	1915	List of nickel minerals; forms of occurrence; nickel resources of United States; analyses of nickel alloys; bibliography.
Platinum and allied metals.	1914	Assaying.
	1915	Mining; bibliography.
	1916	Occurrence.
	1917	Uses.
Quicksilver	1917	Map of United States showing known quicksilver deposits; map showing those quicksilver deposits of world from which some output is on record; bibliography.
Selenium	1914	Full report.
	1915	Bibliography.
Tellurium	1914	Full report.
	1915	Bibliography.
Tin	1917	Map showing world's output of tin in 1916; bibliography.
Tungsten	1910	Occurrence in United States.
	1911	Uses.
	1912	Mining in Burma.
	1916	World's production; mining conditions; bibliography.
Uranium and vanadium (radium).	1912	Resources of United States and foreign countries with special maps and plates; bibliography.
	1915	Bibliography.
Zinc	1908	Full report.
	1915	Map of United States showing location of important zinc-producing districts, zinc smelters, zinc oxide plants, and electrolytic zinc plants.
Secondary metals	1917	Full report
NONMETALLIC.		
Asbestos	1912	Maps of United States; flow sheet of mill.
	1914	Maps of Arizona and California; illustrations of deposits.
	1916	Bibliography.
	1917	Map of Arizona; illustrations of deposits.

Mineral Resources volumes, 1908–1917, which contain particularly full reviews of various industries—Continued.

Mineral.	Year.	Special features.
NONMETALLIC—continued.		
Asphalt	1911	Classification; characteristics; foreign occurrence.
	1914	Bibliography.
	1917	Paved and unpaved streets in 185 cities of United States; production in principal countries.
Barytes	1914	Bibliography.
	1915	Map of United States showing location of barytes deposits and works manufacturing barium products; notes on geology of deposits.
Borax	1913	History of industry.
	1914	World's production; bibliography.
	1916	Map showing location of domestic deposits.
Briquets (fuel)	1915	Full report.
Bromine	1910	Map of United States showing location of salt deposits and bromine works (pocket).
	1917	Full report.
Calcium chloride	1910	Map of United States showing location of salt deposits and calcium chloride works (pocket).
	1916	Uses.
	1917	Method of making.
Cement	1910	Materials and industry of United States.
	1911	Technologic notes.
	1916	Map of United States showing distribution of plants and outlines of Portland cement commercial districts; standard specifications; bibliography.
	1917	Section on concrete ships; bibliography of concrete shipbuilding industry.
Clay	1910	Notes on kaolin of Real (Edwards) County, Tex.
	1912	Notes on the occurrence of different varieties of clays; their classification; their geologic and geographic distribution.
	1913	Notes on occurrence and use of flint clay; bibliography of its occurrence.
	1914	Bibliography of clay-working industries
Coal	1910	Maps of coal fields; bibliography.
	1914	World's production; additional bibliography.
	1917	Production; distribution; consumption.
Coke	1915	Map of United States showing distribution of coke ovens.
Cryolite	1916	Bibliography.
Feldspar	1915	Do.
Flint pebbles for grinding	1914	Bibliography on flint pebbles and substitutes therefor.
Fluorspar	1916	Bibliography.
	1917	Optical fluorite; buyers of fluorspar.
Garnet (abrasive)	1913	Notes on abrasive garnet industry (in chapter on abrasive materials).
Gas (artificial) and by-products.	1915	Full report.
Gas (natural)	1908	Map of United States showing known productive oil and gas fields (pocket).
	1913	Analyses of gases; carbon black from natural gas.
	1914	Bibliography of Survey publications on oil and gas fields of United States (in chapter on petroleum).
Gems and precious stones	1915	Bibliography.
	1916	Selected bibliography for 1916.
	1917	List of gem names.
Graphite	1911	Foreign deposits (Ceylon in particular); bibliography.
	1913	Map showing location of principal graphite mines in Massachusetts, New Jersey, New York, and Pennsylvania; foreign deposits; bibliography.
	1917	World's production; additional bibliography.

Mineral Resources volumes, 1908–1917, which contain particularly full reviews of various industries—Continued.

Mineral.	Year.	Special features.
NONMETALLIC—contd.		
Gypsum	1910	Bibliography.
	1911	Occurrence in United States; additional bibliography.
	1913	Occurrence in United States.
	1916	Map of United States showing location of mills using domestic gypsum.
	1917	Uses.
Lime	1911	Analyses of lime and limestone by States and counties; notes on technologic investigations of lime; bibliography; maps showing location of limekilns in States east of Mississippi River (in chapter on stone).
	1912	Occurrence of limestone and uses to which adapted; maps showing location of limekilns in Great Plains and Rocky Mountain States (in chapter on stone).
	1913	Source, manufacture, and use of lime; additional bibliography; maps showing location of limekilns in States west of Rocky Mountains (in chapter on stone).
Lithium minerals	1916	Only report.
Magnesite	1913	Map of part of California showing distribution of magnesite deposits; uses; foreign occurrence; magnesia cement; bibliography.
	1914	Map of part of California showing distribution of magnesite deposits; derived products; additional bibliography.
	1917	Description of Washington deposits.
Mica	1912	Bibliography.
	1916	World's production.
Mineral paints	1913	Bibliography.
	1914	Additional bibliography.
Mineral waters	1911	Concentration of mineral waters in relation to therapeutic activity.
	1913	Bibliography of published analyses of American mineral waters; discussion of their radioactivity; selected bibliography on radium, radioactivity, and radiotherapy.
	1916	Comparison of American and European mineral waters; bibliography on mineral waters, chiefly American.
Monazite	1911	Bibliography.
	1916	Full report and additional bibliography.
Natural gas	....	See "Gas (natural)."
Oilstones	1911	Oilstones in Arkansas (in chapter on abrasive materials).
Peat	1917	Map of United States showing distribution of peat deposits; industry in foreign countries; bibliography.
Petroleum	1908	Map of United States showing known productive oil and gas fields (pocket).
	1913	Analyses of various oils.
	1914	Bibliography of Survey publications on oil and gas fields of United States.
Phosphate rock	1915	Map of United States showing location of phosphate deposits; conservation; substitutes; tests; bibliography of Survey publications.
Potash	1917	Full report with map, analyses, and bibliography.
Pyrite	1910	Map of United States showing location of pyrite deposits (pocket).
	1917	Domestic deposits.
Salt	1910	Map of United States showing location of salt deposits (pocket).
	1914	Bibliography.
Sand and gravel	1909	Analyses of various sands.
	1911	Glass sand—requirements, preparation, deposits, and analyses.
	1912	Uses and definitions; bibliography.
	1915	Glass sand occurrence; weight per cubic yard of sand and gravel.
Slate	1911	Maps showing location of slate quarries in States east of Mississippi River (in chapter on stone).
	1912	Paper on commercial qualities of slate, by T. Nelson Dale; maps showing location of slate quarries in Great Plains and Rocky Mountain States (in chapter on stone).
	1913	Maps showing location of slate quarries in States west of Rocky Mountains (in chapter on stone).
	1914	Bibliography (in chapter on stone).
	1915	List of colors, uses, location of quarries, and names of producers.

Mineral Resources volumes, 1908–1917, which contain particularly full reviews of various industries—Continued.

Mineral.	Year.	Special features.
NONMETALLIC—contd.		
Sodium salts	1917	Full report.
Stone	1911	Maps showing location of stone quarries in States east of Mississippi River; requirements of limestone for glass making (in chapter on sand and gravel); analyses of limestone by States and counties (in chapter on lime).
	1912	Maps showing location of stone quarries in Great Plains and Rocky Mountain States; occurrence of limestone and uses to which adapted (in chapter on lime).
	1913	Maps showing location of stone quarries in States west of Rocky Mountains.
	1914	Domestic marble; basalt in paper-making machinery; bibliography.
	1916	Weights per cubic yard of various kinds of crushed stone.
Strontium ore	1915	Map of United States and Alaska showing location of strontium ore deposits.
	1916	Full report.
Sulphur	1910	Map of United States showing location of sulphur deposits (pocket); foreign deposits; map of Sicily.
	1916	Notes on all domestic deposits.
Sulphuric acid	1911	Manufacture from smelter fumes at Ducktown, Tenn.
Talc and soapstone	1912	Full report with maps showing location of talc mines and soapstone quarries of Atlantic States, talc mines of California, talc mines and mills of New York, and flow sheet of mill.
	1916	Bibliography of notable recent publications.
Zircon	1911	Bibliography.
	1916	Full report and additional bibliography.
Miscellaneous	1913	Discussion of mineral production by States (in chapter on mineral products of the United States).
	1915	Quantity and value of each mineral from 1880 to 1915, by years (in summary of mineral production).

For a brief historical review of the development of the mineral industries of the United States from 1880 to 1916, inclusive, the reader is referred to the introduction to Mineral Resources for 1916. For a statistical summary of mineral production going back to 1880 the reader is referred to the summary chapter, by Miss Martha B. Clark, in the volume of Mineral Resources for 1915.

VALUE ASSIGNED TO OUTPUT.

The value of the contribution of our metallic output to our industrial needs is best shown by determining the value of the refined or partly refined metal—the marketable product. This value is, of course, ordinarily greater than the value of the ores from which the products are obtained, and the movement of bullion, matte, and refined metal does not at all indicate the volume of ore transported by the railroads and other carriers or the demands made on the transportation lines by the mineral industry as compared with the agricultural and other industries. During recent years the compilation of the statistics of the production of pig iron has been supplemented by an accurate determination of the quantity and value of the iron ore produced, but the quantity and value of pig iron have been retained as units for the iron industry. Many of the ores of the precious and semiprecious metals are complex associations of several metals and gangues, and the same ore may have different values, or none, its value depending on the metallurgic and other treatment it may require. The quantities and values of such ores are therefore best measured by the metal actually extracted from them and made marketable. Chromic iron ore, manganese ore, manganiferous ore, and bauxite, on the other hand, are marketed as such. The quantities and the values of the nonmetals are likewise placed upon the products in the condition in which they are first sold. The quantities and values of the fuels, phosphate rock, and some other nonmetals therefore represent raw or only very slightly dressed products, in the condition in which they first become articles of trade. Salt appears as the content of brine, in various refined conditions, or as rock salt. Gypsum is sold as crude, as ground, or as calcined. Cement, however, is the commercial product reported, rather than the raw material from which it is made. The clay products, except very small quantities of special clays that are sold raw, first appear in statistics as brick, terra cotta, tile, porcelain, pottery, etc. As quarry products are sold in three forms—rough, partly dressed, or finished—there is no way of determining their quantities and values except by considering them in the condition in which they are first marketed.

ACKNOWLEDGMENTS.

The United States Geological Survey is in touch with practically all mineral producers, smelters, refiners, and millmen in this country; with many manufacturers, exporters, and importers of mineral products; and with most operators of prospects, mines, quarries, and wells not producing but undergoing some development or merely held by development work; and it is therefore impossible to make more than general acknowledgment for the vast amount of data contributed by them. Opportunity is taken here, however, to make this acknowledgment as best it may be made and to express grateful appreciation of the trouble taken by correspondents to make the reports of real value. The total number of these correspondents was well over 100,000 in 1917. In the few months succeeding the entrance of the United States into the world war Survey geologists made special field investigations of mineral resources urgently needed and received many courtesies and much aid in this work. Special acknowledgment is made to the miners and millmen for these personal courtesies. Not only through the mails, but also by conferences and by field work of its specialists, the United States Geological Survey continues to keep in close touch with every branch of the mineral industries, and the value of its reports is therefore unique.

ORGANIZATION.

The division of mineral resources of the United States Geological Survey, which is responsible for the annual reports "Mineral Resources of the United States" and related work, was divided during 1917 as in previous years into two sections—the "metals section," which prepares the reports of Part I, and the "nonmetals section," which prepares those of Part II, including fuels, structural materials other than metals, chemical materials, mineral fertilizers, and other nonmetallic products. G. F. Loughlin was the geologist in charge of the nonmetals section, and the writer was charged with administrative supervision of the division, of the metals section, of the western offices, and of cooperative relations with the State geologists.

The western offices were established primarily for the collection and compilation of data for the annual mines reports on the precious and base metals of the Western States, but they have been brought so closely into touch with the mineral industries from the Rocky Mountains to the Pacific coast generally that they now cooperate with the Washington office on many branches of the mineral-resources work and also serve the mining industries and the public at large throughout the West as general bureaus of information and of distribution of Survey publications. The statisticians in charge, all of whom are technically trained along mineral lines, are Charles W. Henderson, 409 New Post Office Building, Denver, Colo.; Victor C. Heikes, 312 Post Office Building, Salt Lake City, Utah; and Charles G. Yale, 305 Customhouse, San Francisco, Calif. Mr. Henderson is author of the mines reports for Colorado, South Dakota, Wyoming, New Mexico, and Texas; Mr. Heikes (assisted by C. N. Gerry) is responsible for the mines reports for Utah, Nevada, Arizona, Montana, Idaho, and Washington; and Mr. Yale contributes the mines reports for California and Oregon, and is coauthor also of the reports on borax and magnesite for the entire country.

The division of mineral resources works in close cooperation with other divisions of the geologic branch, and most of the reports on mineral resources have been written in recent years by geologists working in more than one division, who specialize on the subjects treated by them. The advantage of this arrangement is to utilize the full resources of the Survey in the service of specialists familiar with the occurrence, treatment, and use of the mineral substances covered.

The authors of the reports for 1917 were as follows:

General:
- G. O. Smith—The economic limits to domestic independence in minerals.
- C. K. Leith—International control of minerals.
- H. D. McCaskey—Mineral production of the United States (introduction).
- Martha B. Clark—Mineral production of the United States (summary).

Metals:
- E. S. Bastin—Antimony.
- E. F. Burchard—Iron ore, pig iron, and steel.
- B. S. Butler—Copper; silver and copper in Michigan (mines reports).
- J. S. Diller—Chromite.
- J. P. Dunlop—Silver, copper, lead, and zinc in Central States, except Michigan (mines reports); secondary metals; gold and silver (with H. D. McCaskey).
- C. N. Gerry—Gold, silver, copper, lead, and zinc in Idaho and Washington (mines reports).
- V. C. Heikes—Gold, silver, copper, lead, and zinc in Arizona, Montana, Nevada, and Utah (mines reports).
- C. W. Henderson—Gold, silver, copper, lead, and zinc in Colorado, New Mexico, South Dakota, Texas, and Wyoming (mines reports).
- F. L. Hess—Cobalt, molybdenum, nickel, titanium, tungsten, radium, uranium, and vanadium.
- D. F. Hewett—Manganese and manganiferous ores.
- J. M. Hill—Bauxite and aluminum; gold, silver, copper, lead, and zinc in Eastern States (mines reports); platinum and allied metals.
- Adolph Knopf - Tin.
- H. D. McCaskey—Gold and silver (with J. P. Dunlop).
- G. C. Martin—Gold, silver, copper, and lead in Alaska (mines reports).
- F. L. Ransome—Quicksilver.
- C. E. Siebenthal—Cadmium; lead; zinc.
- R. W. Stone—Magnesium.
- J. B. Umpleby—Arsenic, bismuth, selenium, and tellurium.
- C. G. Yale—Gold, silver, copper, lead, and zinc in California and Oregon (mines reports).

Nonmetals:

E. F. Burchard—Cement; fluorspar and cryolite.
A. T. Coons—Stone (with G. F. Loughlin).
J. S. Diller—Asbestos; talc and soapstone.
A. J. Ellis—Mineral waters.
H. G. Ferguson—Graphite.
H. S. Gale—Potash (with W. B. Hicks).
W. B. Hicks—Potash (with H. S. Gale).
J. M. Hill—Barytes and barium products; strontium.
F. J. Katz—Abrasive materials; feldspar; silica.
C. E. Lesher—Coal; coke (with W. T. Thom, jr.); fuel briquetting.
G. F. Loughlin—Lime; slate; stone (with A. T. Coons).
Jefferson Middleton—Clay-working industries and building operations in the larger cities; fuller's earth; sand-lime brick.
J. D. Northrop—Asphalt, related bitumens, and bituminous rock; natural gas and natural-gas gasoline; petroleum.
C. C. Osbon—Peat.
W. T. Schaller—Gems and precious stones; mica.
P. S. Smith—Sulphur, pyrites, and sulphuric acid.
R. W. Stone—Gypsum; magnesite (with C. G. Yale); phosphate rock; salt, bromine, and calcium chloride; sand and gravel.
W. T. Thom, jr.—Coke (with C. E. Lesher).
R. C. Wells—Sodium salts.
C. G. Yale—Magnesite (with R. W. Stone).

Once more the writer makes acknowledgment of the work done by his colleagues in the preparation of the reports and of the loyal and efficient service given by the statistical, clerical, and stenographic assistants. The group of specialists includes many of the ablest economic geologists, chemists, and engineers of the Survey, and the contributions they make are of special value because of their training in field and office, which especially fits them for the well-rounded study of their respective subjects. Many of the clerical staff have now been connected so long and in so responsible a way with the collection and tabulation of statistics assigned to them that they are most creditably identified with their subjects. Their intelligent scrutiny and criticism of the returns and their skillful interpretation of the results are invaluable in saving the time of the specialists, and their conscientious devotion to duty has maintained the high standards set for accuracy and completeness of the reports.

COOPERATION WITH STATE GEOLOGICAL SURVEYS.

In the collection of data for the reports on mineral resources the United States Geological Survey has had since 1910 the cooperation of many of the corresponding State organizations. The statistics obtained by pooling efforts and field and office facilities are jointly checked and are the official figures of both State and Federal surveys. The objects aimed at in cooperation are mainly the avoidance of duplication of effort on the part of both compilers and operators, and also of divergent sets of figures bearing the official stamp.

Cordial acknowledgment for helpful and most satisfactory cooperation is made to the following State officials for the statistical campaign for 1917:

Alabama: Dr. Eugene A. Smith, State geologist, University.
Florida: Dr. E. H. Sellards, State geologist, Tallahassee.
Georgia: Dr. S. W. McCallie, State geologist, Atlanta.
Illinois: Mr. F. W. De Wolf, director, Urbana.
Iowa: Mr. George F. Kay, director, Iowa City.

Maryland: Dr. Edward B. Mathews, State geologist, Baltimore.
Michigan: Mr. R. C. Allen, director, Lansing.
Minnesota: Dr. W. H. Emmons, director, Minneapolis.
Missouri: Mr. H. A. Buehler, director, Rolla.
New Jersey: Dr. Henry B. Kümmel, State geologist, Trenton.
New York: Dr. John M. Clarke, State geologist, Albany.
North Carolina: Dr. Joseph Hyde Pratt, State geologist, Chapel Hill.
Oregon: Prof. H. M. Parks, director, Portland.
Pennsylvania: Mr. Richard R. Hice, State geologist, Beaver.
Virginia: Dr. Thomas L. Watson, director, Charlottesville.
Washington: Mr. Henry Landes, State geologist, Seattle.
Wisconsin: Dr. W. O. Hotchkiss, State geologist, Madison.

Informal cooperation has been had for some time past between the San Francisco and Washington offices of the United States Geological Survey, on the one hand, and the California State Mining Bureau, under Mr. F. McN. Hamilton, State mineralogist, assisted by Mr. Walter N. Bradley and Mr. E. S. Boalich, on the other; and a most cordial and generous assistance has always been given by this efficient California administration.

Many of the State mine inspectors also ably and cordially cooperated with the United States Geological Survey, especially with regard to the production of fuels.

SUMMARY.

By Martha B. Clark.

GENERAL REMARKS.

The unit of measurement used by the United States Geological Survey for each mineral product in the reports on the mineral resources is that common to the industry concerned, and the variation in these units makes it impracticable, if not impossible, to combine and compare the different minerals except in their value.

In 1899, for the first time, the total value of the mineral production of the United States exceeded $1,000,000,000; in 1905 and 1906 it was more than $1,500,000,000, and in 1907 it exceeded $2,000,000,000. Financial depressions and recoveries from 1907 to 1912 carried the value down and up, with a general advance to 1913, when the total was more than $2,441,000,000. In 1914 the value declined to about $2,118,000,000, but in 1915 it increased to nearly $2,398,000,000, falling short of the record value of 1913 by less than 2 per cent.

In 1916, owing to the demand for increased production of war minerals and to their greater value, especially the metals, the total value (nearly $3,515,000,000) was the greatest in the history of the country up to that time, increasing $1,117,000,000, or 47 per cent, over the $2,398,000,000 recorded for 1915 and exceeding the value of the former record year (1913) by more than $1,000,000,000.

In 1917 the value of mineral production reached a total of nearly $5,008,000,000, advancing $1,500,000,000, or more than 40 per cent, over the great value recorded in 1916. As may be clearly seen from the table on page 30a, this increase does not mean, however, that the mines of the United States contributed in 1917 an additional 40 per cent to the mineral needs of the world. There were decreases in the production of such essential metals as copper, iron, and lead, as well as of gold and silver, and also in the production of practically all building materials and in various other products. The decline in output was, however, not so general among the nonmetallic as among the metallic minerals. The furnace products (pig iron and ferroalloys) together with copper, coal, and petroleum, contributed nearly $3,708,000,000, or 74 per cent, of the total value of minerals produced, and their combined increases were $1,322,000,000, or 89 per cent, of the total increase.

The metals established a new record for value in 1917, exceeding for the first time $2,000,000,000 and representing 42 per cent of the value of all mineral products. They showed an increase of $466,000,000, or 29 per cent, over the former record of $1,620,000,000 in 1916. The increase in the furnace products (pig iron and ferroalloys) and copper was more than $464,000,000, or 99 per cent of the total increase in metallic minerals

The value of the nonmetallic products in 1917 was $2,891,000,000, or 58 per cent of the value of all minerals, increasing more than $1,013,000,000, or 54 per cent, from the former record of $1,878,000,000 in 1916 to $2,891,000,000 in 1917. The increase in coal alone was 66 per cent of the total increase of the nonmetals, and the combined increases of coal and petroleum were 85 per cent of that increase.

As heretofore, coal and iron were the most valuable of our mineral products. The value of coal in 1917 was $1,533,000,000, and that of iron (pig iron) $1,054,000,000. The fuels—coal, natural gas, and petroleum—increased from $1,318,000,000 in 1916 to nearly $2,198,000,000 in 1917, a gain of about $879,000,000, or 67 per cent.

The unspecified products (metallic and nonmetallic), valued in 1917 at $30,110,000 and including the value of antimony other than content of antimonial lead, bismuth, cadmium sulphide, chats or tailings from Missouri zinc mines, chert, a considerable production of diatomaceous earth for special uses, flint lining for tube mills, ilmenite, iron ore sold for magnets and paint, lithium minerals, lithographic stone, magnesium, marls, molybdenum, monazite, pebbles for grinding, selenium, silica sand and sandstone (finely ground), sodium salts (carbonate, bicarbonate, and sulphate) from natural sources, strontium ore, sulphur, and tellurium, and an estimate of the value of miscellaneous mineral products not collected annually by the Geological Survey, bring the total value of the mineral production for 1917 up to $5,007,937,000.

The arrangement of the minerals alphabetically in the metallic and nonmetallic groups will, it is believed, prove to be the most convenient form for reference. It is the plan of the Geological Survey to publish the figures in detail for all years beginning with 1880 in Mineral Resources every fifth year. The detailed figures for the early years appeared in the report for 1915 and will next be shown in the report for 1920. For the intervening years the mineral chart (showing 10 years in detail and totals for all years) will be inclosed in a pocket, as has been the custom in the past, and the chart showing production and value of mineral products through 1917 will be found in the pocket in this report.

The imports cited in this summary are imports "for consumption" (so far as such figures are available) for the calendar year and may or may not be identical with "general" imports. Merchandise brought into the country late in December, for example, may be entered for consumption, or it may be put into a warehouse and not withdrawn for consumption until the following calendar year. It is then credited "for consumption" to the year of its withdrawal from the warehouse.

From the totals shown in the following table, "Mineral products of the United States in 1916 and 1917," duplication has been eliminated wherever practicable. For instance, the value of the coke has been excluded from the totals, as the value of the coal used in its manufacture enters into the statistics of coal production. In mineral paints, the chemically manufactured pigments (white lead, red lead, lithopone, litharge, and orange mineral), whose aggregate value has exceeded $20,000,000 annually for the last 13 years, are not given in the table, as the base from which they are made is included in the output of lead or zinc, whereas the zinc and lead pigments (zinc white or zinc oxide, zinc-lead, leaded zinc oxide, sublimed blue lead, and sublimed white lead) are included, being made in large part directly from the ores and therefore not entering into the lead or zinc totals. The value of the pig iron, rather than that of the iron ore, is included in the total, being considered the best means of presenting the statistics of iron in its first marketable condition. Similarly, the value of the products of the clay industries is included as representing the first marketable condition of the greater part of the clay produced. The quantity and value of the clay mined and sold in the raw state by miners to manufacturers of clay are shown separately, but the value is not included in the total.

Mineral products of the United States in 1916 and 1917.

Product.	1916		1917		Increase or decrease in 1917.		Percentage of increase or decrease in 1917.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
METALLIC.								
Aluminum........pounds..	....	$33,900,000	....	$45,882,000	....	+ $11,962,000	....	+ 35
Antimonial lead [a]........short tons (2,000 pounds)..	24,038	4,483,582	18,646	3,781,560	− 5,392	− 702,022	− 22	− 16
Antimony [b]........do....	(c)	(c)	5,199	[b] 2,152,386	....	....	....	....
Bauxite........long tons (2,240 pounds)..	425,100	2,296,400	568,690	3,119,058	+ 143,590	+ 822,658	+ 34	+ 36
Cadmium........pounds..	135,212	210,931	207,408	305,097	+ 72,196	+ 94,166	+ 53	+ 45
Chromic iron ore........long tons..	47,035	726,243	43,725	1,049,400	− 3,310	+ 323,157	− 7	+ 44
Copper [d], sales value........pounds....	1,927,850,548	474,288,000	1,886,120,721	514,911,000	− 41,729,827	+ 40,623,000	− 2	+ 9
Ferroalloys........long tons..	589,738	50,281,692	634,021	83,731,724	+ 44,283	+ 33,450,032	+ 8	+ 67
Gold [e]........troy ounces..	4,479,056	92,590,300	4,051,440	83,750,700	− 427,616	− 8,839,600	− 10	− 10
Iron:								
Ore [f]........long tons..	77,870,553	[f] 181,902,277	75,573,207	[f] 238,260,444	− 2,297,346	+ 56,358,167	− 3	+ 31
Pig........do....	39,126,324	663,478,118	38,612,546	1,053,785,975	− 513,778	+ 390,307,857	− 1	+ 59
Lead (re-fined) [d]. {1916: Value at New York City / 1917: Sales value} short tons..	552,228	76,207,000	548,450	94,333,000	− 3,778	+ 18,126,000	− .7	+ 24
Manganese ore (35 per cent or more Mn.)..long tons..	31,474	656,278	129,405	4,109,722	+ 97,981	+ 3,453,444	+ 311	+ 526
Manganiferous ore (5 to 35 per cent Mn.)........do....	544,326	1,976,630	860,944	3,406,061	+ 316,618	+ 1,429,431	+ 58	+ 72
Nickel [g] value at New York City........short tons..	918	671,192	402	331,556	− 516	− 339,636	− 56	− 51
Platinum and allied metals (value at New York City)........troy ounces..	28,088	2,301,762	38,831	4,023,757	+ 10,743	+ 1,721,995	+ 38	+ 75
Quicksilver (value at San Francisco)........flasks (75 pounds net)..	29,932	3,768,139	36,159	3,808,266	+ 6,227	+ 40,127	+ 21	+ 1
Silver........troy ounces..	74,414,802	48,953,000	71,740,362	59,078,100	− 2,674,440	+ 10,125,100	− 4	+ 21
Tin (metallic equivalent)........short tons..	140	122,000	110	135,600	− 30	+ 13,600	− 21	+ 11
Titanium ore (rutile)........do....	110	16,500	206	32,960	+ 96	+ 16,460	+ 87	+ 100
Tungsten ore (60 per cent concentrates)........do....	5,923	12,074,000	6,144	6,783,000	+ 221	− 5,291,000	+ 4	− 44
Uranium and vanadium minerals........do....	....	500,000	....	617,000	....	+ 117,000	....	+ 23
Zinc [d] sales value........do....	563,451	151,005,000	584,597	119,258,000	+ 21,146	− 31,747,000	+ 4	− 21
Total value of metallic products (approximate)..	....	1,620,507,000	....	2,086,234,000	....	+ 465,727,000	....	+ 29
NONMETALLIC.								
Arsenious oxide........short tons..	5,986	555,187	6,151	1,118,313	+ 165	+ 563,126	+ 3	+ 101
Asbestos........do....	1,479	448,214	1,683	506,056	+ 204	+ 57,842	+ 14	+ 13
Asphalt........do....	786,811	7,102,132	782,713	8,470,615	− 4,098	+ 1,368,483	− .5	+ 19
Barytes (crude)........do....	221,952	1,011,232	206,888	1,171,184	− 15,064	+ 159,952	− 7	+ 16
Borax (crude)........do....	103,525	2,409,459	108,875	3,609,632	+ 5,350	+ 1,200,173	+ 5	+ 50
Bromine........pounds..	728,520	951,932	895,499	492,703	+ 166,979	− 459,229	+ 23	− 48
Calcium chloride........short tons..	[h] 27,709	[h] 224,997	30,503	451,480	+ 2,794	+ 226,483	+ 10	+ 101
Cement........barrels (376 pounds net)..	95,394,433	104,689,090	91,342,930	123,210,458	− 4,051,503	+ 18,521,368	− 4	+ 18

Clay:								
Products	....	207,200,091	....	248,023,368	....	+ 40,703,277	....	+ 20
Raw *f* ... short tons	2,932,590	*f* 5,751,774	3,113,844	*f* 8,042,546	+ 181,254	+ 2,290,772	+ 6	+ 40
Coal:								
Bituminous *i* ... do	502,519,682	665,116,077	551,790,563	1,249,272,837	+ 49,270,881	+ 584,156,760	+ 10	+ 88
Pennsylvania anthracite ... long tons	78,195,083	202,009,561	88,939,117	283,650,723	+ 10,744,034	+ 81,641,162	+ 14	+ 40
Coke *f* ... short tons	54,533,585	*f* 170,841,197	55,606,828	*f* 298,243,017	+ 1,073,243	+ 127,401,820	+ 2	+ 75
Diatomaceous (infusorial) earth and tripoli	....	*j* 241,553	....	*j* 123,784	....	− 117,769	....	− 49
Emery (also corundum in 1917) ... short tons	15,282	123,901	17,135	241,050	+ 1,853	+ 117,149	+ 12	+ 95
Feldspar ... do	132,681	702,278	141,924	728,838	+ 9,243	+ 26,560	+ 7	+ 4
Fluorspar ... do	155,735	922,654	218,828	2,287,722	+ 63,093	+ 1,365,068	+ 41	+ 148
Fuller's earth ... do	67,822	706,951	72,567	772,087	+ 4,745	+ 65,136	+ 7	+ 9
Garnet for abrasive purposes ... do	6,171	208,850	4,995	198,327	− 1,176	− 10,523	− 19	− 5
Gems and precious stones	....	217,793	....	131,012	....	− 86,781	....	− 40
Graphite:								
Amorphous ... short tons	2,622	20,723	8,301	73,481	+ 5,679	+ 52,758	+ 217	+ 255
Crystalline ... pounds	10,931,989	914,748	10,584,080	1,094,398	− 347,909	+ 179,650	− 3	+ 20
Grindstones and pulpstones	....	766,140	....	1,147,784	....	+ 381,644	....	+ 50
Gypsum ... short tons	2,757,730	7,959,032	2,696,226	11,116,452	− 61,504	+ 3,157,420	− 2	+ 40
Lime ... do	4,073,433	18,509,305	3,786,364	23,807,877	− 287,069	+ 5,298,572	− 7	+ 29
Magnesite (crude) ... do	154,974	1,393,693	316,838	2,899,818	+ 161,864	+ 1,506,125	+ 104	+ 108
Mica:								
Scrap ... do	4,433	69,906	3,429	52,908	− 1,004	− 16,998	− 23	− 24
Sheet ... pounds	865,863	524,485	1,276,533	753,874	+ 410,670	+ 229,389	+ 47	+ 44
Millstones	....	44,559	....	43,489	....	− 1,070	....	− 2
Mineral paints:								
Natural pigments *k* ... short tons	(*k*)	(*k*)	(*k*)	(*k*)	(*k*)	(*k*)	(*k*)	(*k*)
Zinc and lead pigments *l* ... do	135,606	23,515,803	140,636	26,972,137	+ 5,030	+ 3,456,334	+ 4	+ 15
Mineral waters ... gallons sold	55,928,461	5,735,035	46,784,419	4,931,710	− 9,144,042	− 803,325	− 16	− 14
Natural gas	....	120,227,468	....	142,089,334	....	+ 21,861,866	....	+ 18
Natural-gas gasoline ... gallons	103,492,689	14,331,148	217,884,104	40,188,956	+ 114,391,415	+ 25,857,808	+ 111	+ 180
Oilstones, etc	....	154,573	....	168,704	....	+ 14,131	....	+ 9
Peat ... short tons	52,506	369,104	97,363	709,900	+ 44,857	+ 340,796	+ 85	+ 92
Petroleum ... barrels (42 gallons)	300,767,158	330,899,868	335,315,601	522,635,213	+ 34,548,443	+ 191,735,345	+ 12	+ 58
Phosphate rock ... long tons	1,982,385	5,896,993	2,584,287	7,771,084	+ 601,902	+ 1,874,091	+ 30	+ 32
Potash (K_2O) ... short tons	9,720	4,242,730	32,573	13,980,577	+ 22,853	+ 9,737,847	+ 235	+ 230
Pumice ... do	33,320	82,263	35,293	84,814	+ 1,973	+ 2,551	+ 6	+ 3
Pyrite ... long tons	423,556	1,965,702	462,662	2,485,435	+ 39,106	+ 519,733	+ 9	+ 26
Salt ... short tons	6,362,906	13,645,947	6,978,177	19,940,442	+ 615,271	+ 6,294,495	+ 10	+ 46

---

[a] From both domestic and foreign ores.

[b] From all sources. Values excluded from metallic totals as the values of the antimony contained in antimonial lead are included in the antimonial lead values, and the remainder under last item ("Unspecified").

[c] Figures not available. Estimate of value of the antimony other than that entering into antimonial lead included under last item ("Unspecified").

[d] Product from domestic ores only.

[e] Value, $20.671834625323 an ounce.

[f] Value not included in total value.

[g] By-product in electrolytic copper refining.

[h] Figures for 1916 revised in 1917.

[i] Includes brown coal and lignite, and anthracite mined elsewhere than in Pennsylvania.

[j] Exclusive of considerable production for special uses which is included under last item ("Unspecified").

[k] Canvass discontinued after 1915. Value of iron ore sold for paint included under last item ("Unspecified").

[l] Sublimed blue lead, sublimed white lead, leaded zinc oxide, zinc oxide, and zinc lead.

Mineral products of the United States in 1916 and 1917—Continued.

Product.	1916		1917		Increase or decerease in 1917.		Percentage of increase or decrease in 1917.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
NONMETALLIC—continued.								
Sand:								
Glass ....short tons..	2,018,317	$1,957,797	1,942,675	$2,685,014	− 75,642	+ $727,217	− 4	+ 37
Molding, building, etc., and gravel ....do....	87,073,415	27,852,198	74,476,650	32,611,918	− 12,596,765	+ 4,759,720	− 14	+ 17
Sand-lime brick........		1,474,073		1,420,330		− 53,743		− 4
Silica (quartz)........short tons..	88,514	242,786	142,673	318,069	+ 54,159	+ 75,283	+ 61	+ 31
Slate........		5,338,837		5,749,966		+ 411,129		+ 8
Stone........short tons..	91,831,000	[a] 79,069,683	83,562,000	82,215,671	− 8,269,000	+ 3,145,988	− 9	+ 4
Sulphur........long tons..	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Sulphuric acid (60° Baumé) from copper and zinc smelters........short tons..	[c] 1,162,391	14,099,927	[c] 1,455,257	16,890,545	+ 292,866	+ 2,790,618	+ 25	+ 20
Talc and soapstone (exclusive of fibrous talc)...do....	119,725	1,292,293	144,177	1,411,416	+ 24,452	+ 119,123	+ 20	+ 9
Talc, fibrous........do....	93,236	961,510	74,671	881,462	− 18,565	− 80,048	− 20	− 8
Thorium minerals (monazite)........pounds..	37,872	3,400	(b)	(b)				
Total value of nonmetallic products (approximate)........		1,878,463,000		2,891,593,000		+1,013,130,000		+ 54
SUMMARY.								
Total value of metallic products........		1,620,507,000		2,086,234,000		+ 465,727,000		+ 29
Total value of nonmetallic products........		1,878,463,000		2,891,593,000		+1,013,130,000		+ 54
Total estimated value of "unspecified" (metallic and nonmetallic) products [d]........		15,630,000		[d] 30,110,000		+ 14,480,000		+ 93
Grand total approximate value of all mineral products........		3,514,600,000		5,007,937,000		+1,493,337,000		+ 42

---

[a] Figures for 1916 revised in 1917.

[b] Value included under last item ("Unspecified").

[c] Includes 92,802 tons in 1916 and 119,048 tons in 1917 of stronger acid, reported as oleum, etc., not converted to 60° Baumé.

[d] Includes in 1917 antimony other than content of antimonial lead, bismuth, cadmium sulphide, chats, chert, diatomaceous earth for special uses, flint lining for tube mills, ilmenite, iron ore sold for magnets and paint, lithium minerals, lithographic stone, magnesium, marls, molybdenum, monazite, pebbles for grinding, selenium, silica sand and sandstone (finely ground), sodium salts (carbonate, bicarbonate, and sulphate) from natural sources, strontium ore, sulphur, tellurium, and an estimate of the value of miscellaneous mineral products statistics for which are not collected annually by the Survey.

MINERAL PRODUCTION FROM 1880 TO 1917.

The following table and the accompanying diagram show the value of the mineral production of the United States from 1880 to 1917, by years, separating the totals into values for metallic, nonmetallic, and unspecified products. The same principles have been followed in the eliminating of duplication from the totals for the earlier years as were followed for 1916 and 1917. For statistical data regarding any mineral prior to 1880, the first year for which general mineral statistics are available, the reader should consult the special chapter on the mineral concerned. Detailed figures by minerals for the years 1908 to 1917 will be found in the chart which is inclosed in the pocket.

Total value of mineral products of the United States from 1880 to 1917.

Year.	Metallic.	Nonmetallic.	Unspecified (metallic and nonmetallic).	Total.
1880	$187,880,880	$173,581,917	$6,000,000	$367,462,797
1881	189,413,459	207,207,019	6,500,000	403,120,478
1882	215,820,070	230,785,547	6,500,000	453,105,617
1883	197,881,610	243,679,889	6,500,000	448,061,499
1884	180,284,208	221,755,346	5,000,000	407,039,554
1885	172,218,218	242,332,845	5,000,000	419,551,063
1886	204,399,872	250,985,090	800,000	456,184,962
1887	240,791,068	294,041,980	800,000	535,633,048
1888	242,010,000	310,888,983	900,000	553,798,983
1889	250,324,369	291,001,413	1,000,000	542,325,782
1890	303,440,430	310,988,907	1,000,000	615,429,337
1891	280,484,844	319,363,338	1,000,000	600,848,182
1892	283,715,295	337,516,444	1,000,000	622,231,739
1893	223,153,770	321,339,395	1,000,000	545,493,165
1894	186,835,353	362,409,394	1,000,000	550,244,747
1895	248,033,039	393,658,083	1,000,000	642,691,122
1896	252,075,130	387,965,870	1,000,000	641,041,000
1897	269,934,178	380,677,600	1,000,000	651,611,778
1898	308,247,446	417,794,018	1,000,000	727,041,464
1899	483,520,531	525,571,880	1,000,000	1,010,092,411
1900	513,731,959	594,194,796	1,000,000	1,108,926,755
1901	493,313,578	660,764,256	1,000,000	1,155,077,834
1902	604,517,044	722,433,728	1,000,000	1,327,950,772
1903	588,753,010	905,628,365	1,000,000	1,495,381,375
1904	501,114,224	859,074,529	400,000	1,360,588,753
1905	702,584,608	921,181,524	400,000	1,624,166,132
1906	886,179,981	1,016,390,015	200,000	1,902,769,996
1907	904,093,201	1,165,748,197	100,000	2,069,941,398
1908	550,744,388	1,043,702,454	250,000	1,594,696,842
1909	754,940,809	1,131,515,921	300,000	1,886,756,730
1910	749,876,234	1,241,039,986	300,000	1,991,216,220
1911	680,888,929	1,245,676,783	250,000	1,926,815,712
1912	866,381,073	1,378,310,236	500,000	2,245,191,309
1913	883,222,012	1,557,976,159	420,000	2,441,618,171
1914	691,081,734	1,426,754,508	470,000	2,118,306,242
1915	991,729,648	1,398,565,121	7,450,000	2,397,744,769
1916	1,620,507,000	1,878,463,000	15,630,000	3,514,600,000
1917	2,086,234,000	2,891,593,000	30,110,000	5,007,937,000
Grand total	19,990,357,000	28,262,558,000	109,780,000	48,362,695,000

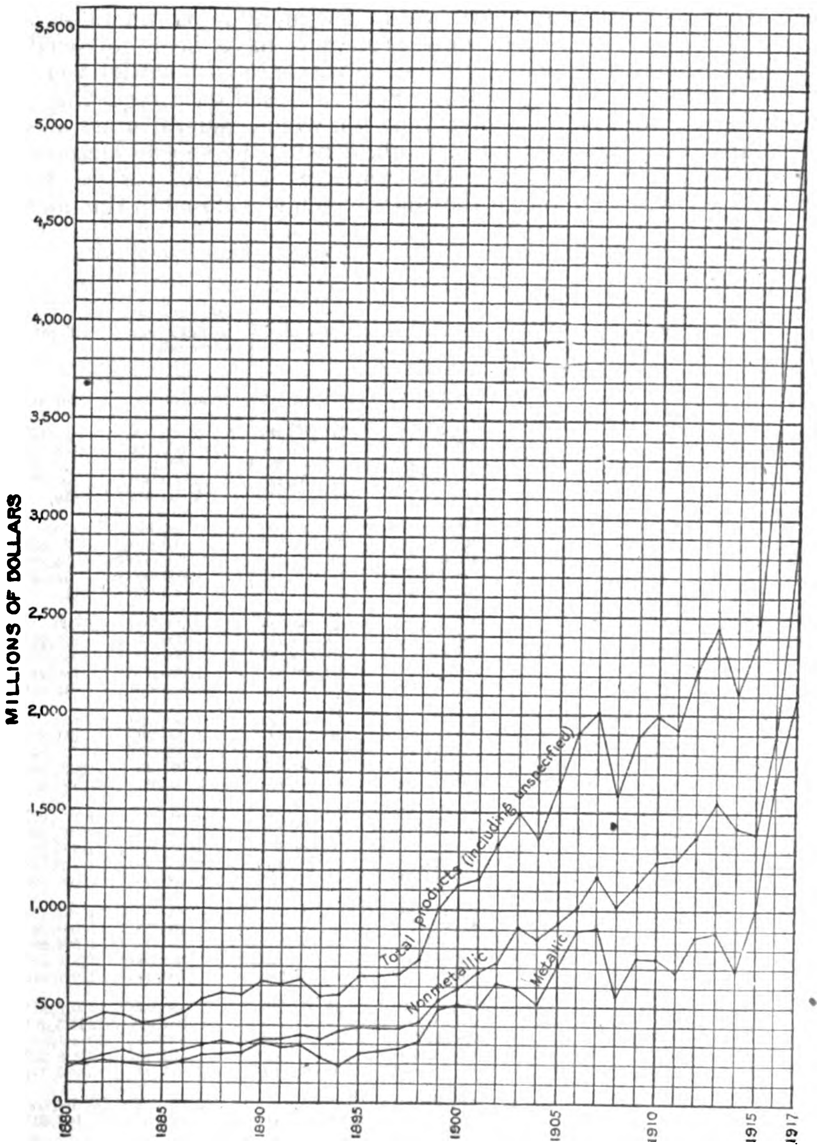


FIGURE A.—Curves showing the value of the mineral production of the United States, 1880-1917.

IMPORTS AND EXPORTS.[1]

Value of imports for consumption and of exports of mineral products in the calendar years 1916 and 1917.

Metallic products.

Product.	1916	1917
IMPORTS.		
Aluminum:		
Crude, plates, sheet, leaf, wire, utensils, and manufactures	$1,785,870	$56,890
Aluminum salts	68,660	39,088
Antimony (crude and ore)	1,072,340	1,006,884
Antimony (metal or regulus)	3,548,507	2,957,819
Antimony (oxide and salts of)	109,832	5,368
Bauxite, crude	87	28,989
Bismuth	195,975	142,300
Brass, fit only for remanufacture	6,578,653	9,949,524
Cerium, cerite, or cerium ore	7	6,700
Chromic iron ore	1,548,402	1,110,659
Chromium salts	75	5,037
Cobalt, and cobalt ore and zaffer	175,236	369,950
Cobalt, oxide of	192,009	275,821
Copper in ore, matte, ingots, manufactures	94,469,458	135,233,853
Copper, sulphate of, or blue vitriol		9,799
Ferroalloys:		
Ferrochrome (and chromium)	1,998	
Ferromanganese	9,240,528	5,710,988
Ferrophosphorus		5,458
Ferrosilicon	384,384	691,684
Ferrotitanium (and titanium)	8,126	
Ferrotungsten (and tungsten)	157,711	3,606
Iron:		
Spiegeleisen		291,594
Tantalum	2,000	
Ore	4,566,514	3,655,392
Lead, in ore, base bullion, pigs, sheets, etc	1,014,959	776,638
Manganese, oxide, and ore of	8,640,065	10,262,929
Nickel, in ore, matte, and oxide, sheets, strips, and manufactures of	9,925,220	9,662,411
Platinum and allied metals:		
Ores of platinum, and unmanufactured	3,138,087	2,408,188
Vases, retorts, all other	21,872	1,347
Iridium, osmium, palladium, rhodium, and ruthenium	533,615	522,206
Osmiridium	17,241	25,456
Quicksilver	515,919	448,032
Tin, bars, blocks, pigs	51,802,232	63,860,340
Scrap (tin plate)	144,281	114,029
Tungsten-bearing ore	7,353,691	4,465,590
Type metal	83,816	
Uranium salts and oxide, including some radium salts	5,065	2,930
Zinc in ore, pigs, sheets, dust, manufactures	4,184,745	1,217,211
Total	211,487,180	255,324,710
Increase in 1917		43,837,530
Percentage of increase in 1917		21
EXPORTS.		
Aluminum and manufactures	15,417,184	[a] 9,029,458
Ingots, metal and alloys		[b] 4,269,643
Plates and sheets		[b] 301,550
All other manufactures		[b] 985,816
Bauxite concentrates	987,454	1,323,926
Brass, scrap and old	1,305,050	1,758,384
Copper:		
Ore	1,006,826	1,410,072
Concentrates, matte, and regulus	232,241	206,888
Unrefined, black blister, in pigs, bars, etc	5,193,278	4,614,843
Refined copper in ingots, pigs, bars, etc	186,266,158	306,847,639
Composition metal		[b] 350,561
Old and scrap	203,493	300,609
Pipes and tubes		[b] 3,023,563
Plates and sheets	6,874,571	12,995,508
Wire, except insulated	6,386,674	8,975,078
All other manufactures	25,752,591	16,957,876
Copper, sulphate of (blue vitriol)	2,803,833	3,038,380

[a] Figures cover six months January to June. Classification changed July 1.

[b] Classification changed July 1. Figures cover six months July to December..

---

[1] Compiled by James A. Dorsey from records of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce.

Value of imports for consumption and of exports of mineral products in the calendar years 1916 and 1917—Continued.

Metallic products—Continued.

Product.	1916	1917
EXPORTS—continued.		
Iron:		
Ore	$3,702,496	$4,464,111
Pig	15,381,431	[a] 12,998,026
Ferromanganese	....	[b] 498,402
Ferrosilicon	....	[b] 719,626
All others	....	[b] 9,820,997
Ferrovanadium	2,035,276	2,953,260
Tungsten and ferrotungsten	1,352,631	1,122,653
Scrap and old, fit only for remanufacture	3,689,675	3,362,562
Lead:		
Pigs, bars, etc	13,494,065	9,560,598
Other manufactures of	2,522,416	2,287,305
Nickel, nickel oxide, and matte	12,952,493	8,936,620
Manufactures of	1,674,600	1,527,353
Platinum:		
Unmanufactured	97,988	234,433
Manufactured	83,864	65,415
Quicksilver	670,475	998,470
Tin, in pigs, bars	365,176	232,401
Zinc:		
Ore	3,992	63,043
Dross	10,801	2,126,909
In pigs, slabs, etc	46,770,901	32,605,767
Rolled in sheets, strips, etc	4,540,146	5,730,792
All other manufactures	572,229	570,352
Total	362,349,958	480,267,884
Increase in 1917	....	117,917,926
Percentage of increase in 1917	....	33

Nonmetallic products.

IMPORTS.		
Arsenic, sulphides, etc	$232,694	$674,875
Sheep dip	20,134	15,848
Asbestos:		
Unmanufactured	3,303,470	4,521,172
Manufactured	24,282	15,646
All other	113,636	47,041
Asphalt	734,712	993,115
Barium products:		
Manufactured barytes	2,072	1,743
Lithopone (including zinc sulphides)	414,592	35,718
Barium carbonate—		
Natural	18,169	17,321
Manufactured	....	1,554
Barium binoxide	6,590	....
Barium chloride	608	....
Blanc-fixe	17,810	3,333
Barytes, crude	245	63
Borax (including crude, refined, and boracic acid, etc.)	20,043	21,206
Burrstones and millstones	19,816	18,227
Cement, hydraulic	4,942	6,076
Chalk:		
Crude	112,671	126,605
Ground or bolted	....	6,241
Precipitated	27,713	29,960
Cubes, blocks, sticks, tailor's, etc	4,096	6,563
French, cut, powdered, washed, etc	628	222
Manufactures of (not elsewhere specified)	249	340
Clay:		
Kaolin or china clay	1,326,684	1,315,769
Other than kaolin	177,549	126,290
Clay products:		
Brick and tile	164,247	307,802
Flattening stones	833	1,457
Pipes, common tobacco pipes, and pipe bowls of clay	10,378	8,209
Pottery, etc	5,590,207	6,325,105
Coal:		
Anthracite	7,202	18,155
Bituminous	4,736,631	4,823,478

[a] Figures cover six months January to June. Classification changed July 1.

[b] Classification changed July 1. Figures cover six months July to December.

Value of imports for consumption and of exports of mineral products in the calendar years 1916 and 1917—Continued.

Nonmetallic products—Continued.

Product.	1916	1917
IMPORTS—continued.		
Coke	$249,514	$146,451
Corundum and emery	240,737	210,602
Cryolite	165,222	218,500
Diatomaceous earth, rotten stone, and tripoli	37,573	17,864
Explosives:		
Fulminates, fulminating powders, etc.—		
Suitable for miners		75,839
All other	229,194	1,848,802
Gunpowder and all other substances (not elsewhere specified)	7,259,814	2,539,249
Mining, blasting, or safety fuses of all kinds	3,378	5,016
Percussion caps	3,123	525
Blasting caps	2,453	
Bombs, rockets, Roman candles, and fireworks	1,507	3,413
Fire crackers	291,830	384,696
Fertilizers:		
Crude guano, kainite, manure salts, and phosphate	4,104,647	4,914,283
Potassium chloride	348,961	158,410
Potassium sulphate	81,684	21,702
Other potassium salts	1,921,803	1,034,284
Sodium nitrate	38,131,364	60,727,100
Flint, flints, and flint stones	313,120	197,156
Fluorspar	54,000	114,598
Fuller's earth	139,664	176,417
Gems and precious stones (including diamond dust and bort)	38,930,117	34,846,351
Granite	75,697	35,042
Graphite	7,279,884	8,961,988
Grindstones, finished and unfinished	63,277	57,950
Gypsum	356,473	381,252
Keenes cement, or other cement of which gypsum is chief value	9,890	8,003
Hones, oilstones, and whetstones	10,614	10,636
Ichthyol	93,762	36,282
Lead paints, litharge, orange mineral, red lead, white lead	21,783	6,870
Lime	71,663	70,505
Lithographic stones, not engraved	983	
Magnesia	19,743	17,761
Magnesite	838,630	464,706
Marble and stone (exclusive of granite)	883,670	646,433
Mica	1,071,356	1,430,048
Mineral waters	624,302	268,665
Mineral salts, obtained by evaporation from mineral waters		4,858
Monazite sand and thorium oxide	197,870	355,017
Ocher	181,153	234,490
Peat	27,859	4,966
Petroleum:		
Crude	12,602,811	16,400,017
Benzine, gasoline, and naphtha	185,286	1,411,453
Ozokerite	196,185	90,510
Paraffin oil	75,925	3,514
Paraffin wax	510,689	638,700
All other	1,023,241	2,793,701
Carbon made entirely from petroleum coke	3,925	
Pumice stone	116,543	147,278
Pyrite	6,728,318	5,981,457
Salt	342,588	280,135
Sand	87,144	142,586
Selenium	302	2,236
Sienna and sienna earths	82,999	57,330
Slate	2,200	1,024
Strontium salts	11,049	23,216
Sulphur or brimstone	404,784	29,340
Talc	230,875	269,497
Thorium nitrate	3,884	2,359
Umber	69,470	42,620
Venetian red	10,811	5,967
Zinc oxide	185,395	53,525
Total	144,305,641	168,482,249
Increase in 1917		24,176,608
Percentage of increase in 1917		17

Value of imports for consumption and of exports of mineral products in the calendar years 1916 and 1917—Continued.

Nonmetallic products—Continued.

Product.	1916	1917
EXPORTS.		
Abrasives:		
Wheels, emery and other	$2,240,227	$4,481,600
All other	2,035,951	1,941,512
Asbestos:		
Ore and unmanufactured	6,133	116,580
Manufactured	1,209,076	1,932,551
Asphalt:		
Unmanufactured	759,769	587,256
Manufactures of	494,895	585,472
Cement	3,828,231	5,328,536
Clay:		
Fire	144,552	268,098
All other	145,970	178,764
Coal:		
Anthracite	22,470,147	30,909,798
Bituminous	[a] 45,828,092	[a] 79,502,654
Coke	4,202,236	8,543,746
Earthen, stone, and chinaware:		
Brick—		
Building	189,668	196,207
Fire	2,406,184	4,011,546
Chinaware	262,119	422,641
Earthen and stoneware	600,377	805,784
Sanitary earthenware	214,076	323,558
Tiles except drain	403,184	450,422
All other	779,922	743,105
Fertilizers:		
Phosphate rock, ground or unground—		
High-grade hard rock	286,948	113,392
Land pebble	863,078	548,203
All other	6,365	173,450
Graphite:		
Unmanufactured	98,118	349,563
Manufactured	1,339,259	891,687
Lime	132,769	168,671
Mica:		
Unmanufactured	4,544	3,073
Manufactures of	74,127	71,412
Paints:		
Red lead	....	[b] 267,238
White lead	2,137,072	2,089,659
Zinc oxide	2,394,709	3,148,898
Petroleum and petroleum products:		
Crude	7,029,923	7,668,312
Gasoline	33,614,957	49,049,647
Naphtha	35,045,924	44,084,597
Illuminating	55,862,906	48,953,610
Fuel oil and gas oil	[c] 26,990,552	[c] 45,549,282
Lubricating and heavy paraffin oil	43,027,371	[d] 26,108,011
Paraffin oil	....	[b] 1,192,297
All other	....	[b] 30,264,556
Jelly, etc	1,041,408	1,246,901
Paraffin and paraffin wax	14,820,440	17,906,706
Residuum	149,658	107,164
Plaster, builder's and common	129,872	159,875
Wall board (suitable for plaster)	108,505	106,118
Potash:		
Chlorate	....	[b] 475,434
All other	....	[b] 638,768
Salt	567,441	1,000,773
Sand and gravel	233,310	494,251
Soda	17,003,998	[d] 9,322,283
Caustic	....	[b] 5,832,598
Sal soda	....	[b] 97,772
Silicate	....	[b] 216,828
Soda ash	....	[b] 2,884,569
Other salts of soda	....	[b] 4,030,196

[a] Not including bunker coal laden as fuel on vessels in the foreign trade, which aggregated in value $27,491,822 in 1916 and $31,844,799 in 1917.

[b] Classification changed July 1. Figures cover six months July to December.

[c] Not including fuel or bunker oil laden as fuel on vessels in the foreign trade, which aggregated in value $5,583,222 in 1916 and $7,391,985 in 1917.

[d] Figures cover six months January to June. Classification changed July 1.

Value of imports for consumption and of exports of mineral products in the calendar years 1916 and 1917—Continued.

Nonmetallic products—Continued.

Product.	1916	1917
EXPORTS—continued.		
Stone, including marble:		
Unmanufactured	$403,303	$572,097
Manufactures of—		
Grindstones	176,563	198,772
Roofing slate	27,630	27,113
All other	1,077,447	1,108,185
Sulphur or brimstone	2,505,857	3,500,819
Total	335,374,863	451,952,555
Increase in 1917		116,577,692
Percentage of increase in 1917		35

Summary.

Imports:		
Metallic	$211,487,180	$255,324,710
Increase		43,837,530
Percentage of increase		21
Nonmetallic	144,305,641	168,482,249
Increase		24,176,608
Percentage of increase		17
Exports:		
Metallic	362,349,958	480,267,884
Increase		117,917,926
Percentage of increase		33
Excess of exports over imports	150,862,778	224,943,174
Excess of exports over imports (percentage)	71	88
Nonmetallic	335,374,863	451,952,555
Increase		116,577,692
Percentage of increase		35
Excess of exports over imports	191,069,222	283,470,306
Excess of exports over imports (percentage)	132	168
Grand total value:		
Imports of metallic and nonmetallic products	355,792,821	423,806,959
Increase		68,014,138
Percentage of increase		19
Exports of metallic and nonmetallic products	697,724,821	932,220,439
Increase		234,495,618
Percentage of increase		34
Excess of exports over imports	341,932,000	508,413,480
Excess of exports over imports (percentage)	96	120

PRODUCTION BY STATES.

In the following tables are shown (1) the value of the mineral production of the United States in 1917 arranged by minerals in order of value, with the States leading in the production of each mineral, and the percentage which each mineral represents of the total value for the entire country, and (2) the quantity and value of the principal metals, fuels, and structural materials in 1916 and 1917 arranged in groups in order of value in 1917, with States leading in the production of each mineral, and with the increase or decrease by minerals and by groups in 1917.

It is of interest to note that more than 51 per cent of the total value of mineral production may be credited to coal and pig iron, and that with the addition of petroleum and copper these minerals yielded nearly three-fourths of the entire value. Pennsylvania was the leading State in the production of 11 mineral products and California of 7. Coal was the product of greatest value in 16 States in 1917. The leading States in value of output in 1917 were as follows: Pennsylvania, West Virginia, Oklahoma, Illinois, Ohio, Arizona, California, and Michigan; 1916: Pennsylvania, Arizona, West Virginia, Oklahoma, Illinois, Ohio, Montana, and Michigan.

Mineral products of the United States in 1917, in order of value.

Rank.	Mineral.	Principal producing States (in order of value).[a]	Value.	Percentage of total for United States.
1	Coal:			
	Bituminous	Pennsylvania, West Virginia, Illinois, Ohio	$1,249,272,837	24.95
	Pennsylvania anthracite.	Pennsylvania	283,650,723	5.66
2	Iron, pig	Pennsylvania, Ohio, Illinois, Alabama	1,053,785,975	21.04
3	Petroleum	Oklahoma, California, Kansas, Texas	522,635,213	10.44
4	Copper	Arizona, Montana, Michigan, Utah	514,911,000	10.28
5	Coke	Pennsylvania, Alabama, Ohio, Indiana	[b] 298,243,017	[b] 5.96
6	Clay products	Ohio, Pennsylvania, New Jersey, Illinois	248,023,368	4.95
7	Iron ore	Minnesota, Michigan, Alabama, New York	[b] 238,260,444	[b] 4.76
8	Natural gas	West Virginia, Pennsylvania, Ohio, Oklahoma	142,089,334	2.84
9	Cement	Pennsylvania, Indiana, Missouri, California	123,210,458	2.46
10	Zinc	Missouri, New Jersey, Montana, Oklahoma	119,258,000	2.38
11	Lead	Missouri, Idaho, Utah, Colorado	94,333,000	1.88
12	Gold	California, Colorado, Alaska, South Dakota	83,750,700	1.67
13	Ferroalloys	Pennsylvania, Illinois, Maryland, Alabama	83,731,724	1.67
14	Stone	Pennsylvania, Ohio, Vermont, New York	82,215,671	1.64
15	Silver	Utah, Montana, Idaho, Nevada	59,078,100	1.18
16	Aluminum	New York, Tennessee, North Carolina	45,882,000	.92
17	Natural-gas gasoline	Oklahoma, West Virginia, California, Pennsylvania	40,188,956	.80
18	Sand and gravel	Pennsylvania, Ohio, Illinois, New York	35,296,932	.70
19	Mineral paints (zinc and lead pigments.	Pennsylvania, Wisconsin, Kansas, Missouri	26,972,137	.54
20	Sulphur	Louisiana, Texas, Wyoming, Nevada	(c)	(c)
21	Lime	Pennsylvania, Ohio, Virginia, Missouri	23,807,877	.48
22	Salt	Michigan, New York, Ohio, Kansas	19,940,442	.40
23	Sulphuric acid from copper and zinc smelters.	Pennsylvania, Illinois, Ohio, Tennessee	16,890,545	.34
24	Potash (K_2O)	Nebraska, California, Utah, Maryland	13,980,577	.28
25	Gypsum	New York, Iowa, Michigan, Ohio	11,116,452	.22
26	Asphalt	Texas, California, Oklahoma, Illinois	8,470,615	.17
27	Clay, raw	Missouri, Pennsylvania, New Jersey, Illinois	[b] 8,042,546	[b] .16
28	Phosphate rock	Florida, Tennessee, South Carolina, Kentucky	7,771,084	.16
29	Tungsten ore	California, Colorado, South Dakota, Nevada	6,783,000	.14
30	Slate	Pennsylvania, Vermont, Maine, Virginia	5,749,966	.11

[a] Rank of States in metal production (except pig iron) arranged according to mines reports, not smelter output.

[b] Not included in total value.

[c] Included under last item ("Unspecified").

Mineral products of the United States in 1917, in order of value—Continued.

Rank.	Mineral.	Principal producing States (in order of value).	Value.	Percentage of total for United States.
31	Mineral waters	Wisconsin, New York, California, Maine	$4,931,710	0.10
32	Manganese ore	Montana, Virginia, Arizona, Arkansas	4,109,722	1.00
33	Platinum and allied metals.	Nevada, California, Wyoming, Oregon	4,023,757	
34	Quicksilver	California, Texas, Nevada, Oregon	3,808,266	
35	Antimonial lead	Not separable by States	3,781,560	
36	Borax (crude)	California	3,609,632	
37	Manganiferous ore	Minnesota, Colorado, Arizona, Michigan	3,406,061	
38	Bauxite	Arkansas, Georgia, Alabama, Tennessee	3,119,058	
39	Magnesite (crude)	California, Washington	2,899,818	
40	Pyrite	Virginia, New York, California, Georgia	2,485,435	
41	Talc and soapstone	New York, Vermont, Virginia, Georgia	2,292,878	
42	Fluorspar	Illinois, Kentucky, Colorado, New Hampshire	2,287,722	
43	Antimony [a]	Nevada, Alaska, Utah, Idaho	[a] 2,152,386	
44	Sand-lime brick	Michigan, Minnesota, New York, Massachusetts	1,420,330	
45	Barytes (crude)	Georgia, Missouri, Tennessee, Kentucky	1,171,184	
46	Graphite	Alabama, New York, Pennsylvania, Rhode Island.	1,167,879	
47	Grindstones and pulpstones.	Ohio, West Virginia, Michigan	1,147,784	
48	Arsenious oxide	Not separable by States	1,118,313	
49	Chromic iron ore	California, Oregon, Maryland, Washington	1,049,400	
50	Mica	North Carolina, New Hampshire, Virginia, Georgia.	806,782	
51	Fuller's earth	Florida, Georgia, Texas, Arkansas	772,087	
52	Feldspar	Maine, North Carolina, Pennsylvania, Connecticut.	728,838	
53	Peat	New Jersey, Illinois, California, Massachusetts	709,900	
54	Uranium and vanadium minerals.	Colorado, Utah	617,000	
55	Asbestos	Arizona, Georgia, California, Wyoming	506,056	
56	Bromine	Michigan, Ohio, West Virginia, Pennsylvania	492,703	
57	Calcium chloride	Michigan, Ohio, West Virginia, California	451,480	
58	Nickel	Not separable by States	331,556	
59	Silica (quartz)	Massachusetts, Pennsylvania, Wisconsin, North Carolina.	318,069	
60	Cadmium	Not separable by States	305,097	
61	Emery and corundum.	New York, North Carolina, Virginia	241,050	
62	Garnet for abrasive purposes.	New York, New Hampshire, North Carolina	198,327	
63	Oilstones, etc	Arkansas, Indiana, Ohio, Vermont	168,704	
64	Tin	Alaska, South Dakota	135,600	
65	Gems and precious stones.	Montana, Nevada, California, Maine	131,012	
66	Diatomaceous (infusorial) earth and tripoli.	California, Pennsylvania, Illinois, Washington	[b] 123,784	
67	Pumice	Kansas, Nebraska, California	84,814	
68	Millstones	New York, Virginia, North Carolina, Pennsylvania.	43,489	
69	Titanium ore (rutile).	Virginia	32,960	
	Total estimated value of "Unspecified" products.		30,110,000	.60
	Grand total (approximate).	Pennsylvania, West Virginia, Oklahoma, Illinois, Ohio, Arizona.	5,007,937,000	100.00

---

[a] Value excluded from total, except value of antimony other than that entering into antimonial lead which is included under last item ("Unspecified"). States are arranged in order of value of antimony ore produced.

[b] Exclusive of considerable production for special uses which is included under last item ("Unspecified").

Production and value of principal metals, fuels, and structural materials in the United States, 1916 and 1917.

Mineral.	Principal producing States in 1917 (in order of value).[a]	1916			1917			Increase (+) or decrease (−) in value.			
								By minerals.		By groups.	
		Quantity.	Value.	Value by groups.	Quantity.	Value.	Value by groups.	Amount.	Per cent.	Amount	Per cent.
Metals (from domestic ores):											
Pig iron, long tons.	Pennsylvania, Ohio, Illinois, Alabama.	38,361,474	$647,481,362	$1,490,524,662	38,107,330	$1,039,404,779	$1,910,735,579	+$391,923,417	+61	+$420,210,917	+28
Copper...pounds..	Arizona, Montana, Michigan, Utah.	1,927,850,548	474,288,000		1,886,120,721	514,911,000		+ 40,623,000	+ 9		
Zinc...short tons..	Missouri, New Jersey, Montana, Oklahoma.	563,451	151,005,000		584,597	119,258,000		− 31,747,000	−21		
Lead..short tons..	Missouri, Idaho, Utah, Colorado.	552,228	76,207,000		548,450	94,333,000		+ 18,126,000	+24		
Gold.troy ounces..	California, Colorado, Alaska, South Dakota.	4,479,056	92,590,300		4,051,440	83,750,700		− 8,839,600	−10		
Silver.troy ounces.	Utah, Montana, Idaho, Nevada.	74,414,802	48,953,000		71,740,362	59,078,100		+ 10,125,100	+21		
Fuels:											
Coal...short tons..	Pennsylvania, West Virginia, Illinois, Ohio.	590,098,175	867,125,638	1,318,252,974	651,402,374	1,532,923,560	2,197,648,107	+665,797,922	+77	+879,395,133	+67
Petroleum.barrels.	Oklahoma, California, Kansas, Texas.	300,767,158	330,899,868		335,315,601	522,635,213		+191,735,345	+58		
Natural gas.......	West Virginia, Pennsylvania, Ohio, Oklahoma.	....	120,227,468		....	142,089,334		+ 21,861,866	+18		

Structural materials:											
Clay products (brick and tile).	Pennsylvania, Ohio, Illinois, Missouri.	....	159,042,849	404,418,791	....	191,860,846	473,258,202	+ 32,817,997	+21	+ 68,839,411	+17
Cement...barrels..	Pennsylvania, Indiana, Missouri, California.	93,394,433	104,689,090		91,342,930	123,210,458		+ 18,521,368	+18		
Stone..short tons..	Pennsylvania, Ohio, Vermont, New York.	91,831,000	79,069,683		83,562,000	82,215,671		+ 3,145,988	+ 4		
Sand and gravel, ...short tons..	Pennsylvania, Ohio, Illinois, New York.	89,091,732	29,809,995		76,419,325	35,296,932		+ 5,486,937	+18		
Lime........do....	Pennsylvania, Ohio, Virginia, Missouri.	4,073,433	18,509,305		3,786,364	23,807,877		+ 5,298,572	+29		
Gypsum....do....	New York, Iowa, Michigan, Ohio.	2,757,730	7,959,032		2,696,226	11,116,452		+ 3,157,420	+40		
Slate.............	Pennsylvania, Vermont, Maine, Virginia.	....	5,338,837		....	5,749,966		+ 411,129	+ 8		

[a] Rank of States in metal production (except pig iron) arranged according to mines reports, not smelter output.

The following tables show (1) the value of the mineral production of the United States in 1916 and 1917, arranged by States in order of productive value in 1917, with leading products in each State, increase or decrease in each State, and percentage of total for the United States represented by each State in 1917; (2) value of mineral production by States, arranged alphabetically, from 1911 to 1917; and (3) table of production for each State alphabetically for 1916 and 1917, giving quantity and value of each mineral produced in the State and total value of the State's output.

For more detailed accounts of the products the reader should consult the chapters of Mineral Resources on the different minerals.

Rank of States in value of mineral production in 1916 and 1917.

State.	Principal mineral products in 1917 (in order of value).[a]	1916		1917				
		Rank.	Value.	Rank.	Value.	Increase or decrease.	Percentage of increase or decrease.	Percentage of total for United States.
Pennsylvania	Coal, clay products, cement, natural gas	1	$554,501,375	1	$880,220,510	+$325,719,135	+58.7	21.6
West Virginia	Coal, natural gas, petroleum, clay products	3	187,043,011	2	306,916,191	+119,873,180	+64.1	7.5
Oklahoma	Petroleum, natural-gas gasoline, zinc, natural gas	4	169,556,331	3	259,134,377	+89,578,046	+52.8	6.4
Illinois	Coal, petroleum, clay products, cement	5	146,359,792	4	236,934,229	+90,574,437	+61.9	5.8
Ohio	Coal, clay products, petroleum, natural gas	6	145,088,485	5	218,181,419	+73,092,934	+50.4	5.4
Arizona	Copper, silver, gold, zinc	2	192,622,991	6	212,615,978	+19,992,987	+10.4	5.2
California	Petroleum, gold, copper, cement	9	137,284,754	7	175,401,518	+38,116,764	+27.8	4.3
Michigan	Copper, iron ore, salt, cement	8	140,666,124	8	163,997,853	+23,331,729	+16.6	4.0
Minnesota	Iron ore, clay products, cement, manganiferous ore	10	113,662,522	9	152,490,554	+38,828,032	+34.2	3.7
Montana	Copper, zinc, silver, coal	7	142,650,179	10	123,733,415	−18,916,764	−13.3	3.0
Utah	Copper, lead, silver, coal	12	99,734,209	11	113,589,282	+13,855,073	+13.9	2.8
Kansas	Petroleum, coal, natural gas, cement	21	41,847,955	12	106,763,055	+64,915,100	+155.1	2.6
Missouri	Lead, zinc, coal, clay products	11	102,424,953	13	105,320,378	+2,895,425	+2.8	2.6
Indiana	Coal, cement, clay products, stone	15	56,926,558	14	85,079,370	+28,152,812	+49.5	2.1
Colorado	Coal, gold, zinc, silver	13	77,642,778	15	80,586,021	+2,943,243	+3.8	2.0
Texas	Petroleum, sulphur, coal, cement	19	47,711,571	16	77,552,369	+29,840,798	+62.5	1.9
Kentucky	Coal, petroleum, clay products, stone	23	40,015,935	17	77,177,421	+37,161,486	+92.9	1.9
Alabama	Coal, iron ore, clay products, stone	22	40,922,462	18	65,371,469	+24,449,007	+59.7	1.6
New Jersey	Zinc, clay products, cement, iron ore	14	59,430,705	19	57,710,181	−1,720,524	−2.9	1.4
Nevada	Copper, silver, gold, lead	16	53,510,559	20	55,410,190	+1,899,631	+3.6	1.4
Idaho	Lead, silver, zinc, copper	17	49,249,134	21	55,224,026	+5,974,892	+12.1	1.4
New York	Clay products, iron ore, cement, stone	20	45,619,119	22	52,123,552	+6,504,433	+14.3	1.3
New Mexico	Copper, coal, zinc, silver	24	37,123,501	23	43,312,947	+6,189,446	+16.7	1.1
Alaska	Copper, gold, silver, coal	18	48,521,513	24	40,710,655	−7,810,858	−16.1	1.0
Iowa	Coal, clay products, cement, gypsum	25	30,210,284	25	39,336,372	+9,126,088	+30.2	1.0
Tennessee	Coal, zinc, copper, cement	26	28,277,365	26	36,910,448	+8,633,083	+30.5	.9
Louisiana	Petroleum, sulphur, natural gas, natural-gas gasoline	27	28,020,543	27	36,204,387	+8,183,844	+29.2	.9
Virginia	Coal, lime, clay products, stone	29	20,560,956	28	32,243,648	+11,682,692	+56.8	.8
Wyoming	Coal, petroleum, iron ore, copper	30	19,683,292	29	29,567,250	+9,883,958	+50.2	.7
Wisconsin	Zinc, iron ore, stone, mineral waters	28	27,082,175	30	24,976,780	−2,105,395	−7.8	.6
Maryland	Coal, clay products, cement, stone	32	13,335,013	31	19,617,596	+6,282,583	+47.1	.5
Washington	Coal, cement, clay products, lead	31	14,521,014	32	18,576,052	+4,055,038	+27.9	.5
Arkansas	Coal, bauxite, zinc, clay products	33	9,508,001	33	12,061,702	+2,553,701	+26.9	.3
Vermont	Stone, slate, talc and soapstone, lime	35	8,297,104	34	8,980,573	+683,469	+8.2	.2
South Dakota	Gold, tungsten ore, stone, silver	34	8,696,680	35	8,348,684	−347,996	−4.0	.2
Nebraska	Potash (K_2O), clay products, stone, sand and gravel	43	3,436,774	36	7,943,729	+4,506,955	+131.1	.2
Georgia	Clay products, stone, barytes, cement	36	6,779,828	37	7,650,553	+870,725	+12.8	.2

Florida	Phosphate rock, stone, fuller's earth, clay products	38	5,666,785	38	7,294,467	+	1,627,682	+ 28.7	.2
Massachusetts	Stone, clay products, lime, sand and gravel	37	6,697,444	39	7,225,750	+	528,306	+ 7.9	.2
North Carolina	Stone, clay products, mica, iron ore	39	4,595,551	40	5,246,391	+	650,840	+ 14.2	.1
Oregon	Gold, copper, stone, clay products	40	4,498,632	41	4,074,247	−	424,385	− 9.4	.1
Connecticut	Clay products, stone, lime, sand and gravel	41	3,940,676	42	3,981,203	+	40,527	+ 1.0	.1
Maine	Stone, lime, clay products, mineral waters	42	3,539,481	43	3,726,121	+	186,640	+ 5.3	.1
North Dakota	Coal, clay products, mineral waters, sand-lime brick	46	1,283,809	44	1,749,549	+	465,740	+ 36.3	.2
New Hampshire	Stone, clay products, mica, sand and gravel	44	1,817,723	45	1,594,584	−	223,139	− 12.3	
South Carolina	Clay products, stone, phosphate rock, mineral waters	45	1,392,073	46	1,393,297	+	1,224	+ .1	
Mississippi	Clay products, sand and gravel, mineral waters, stone	47	890,566	47	966,135	+	75,569	+ 8.5	
Rhode Island	Stone, clay products, graphite, mineral waters	48	789,208	48	717,123	−	72,085	− 9.1	
Delaware	Stone, clay products, sand and gravel, mineral waters	49	336,172	49	523,991	+	187,819	+ 55.9	
District of Columbia	Clay products, sand-lime brick, stone, mineral waters	50	179,436	50	204,936	+	25,500	+ 14.2	

---

[a] In this table iron ore, not pig iron, is taken as the basis of iron valuation, and in the case of other metals mine production (recoverable content of metals) is the basis..

Value of mineral production, 1911 to 1917, by States.[a]

State.	1911	1912	1913	1914	1915	1916	1917
Alabama	$28,005,785	$30,641,983	$34,660,545	$30,879,288	$29,458,157	$40,922,462	$65,371,469
Alaska	20,866,122	22,732,947	19,645,498	19,177,051	32,854,011	48,521,513	40,710,655
Arizona	44,503,873	67,497,838	71,429,705	60,420,362	91,552,049	192,622,991	212,615,978
Arkansas	5,864,822	6,258,726	6,780,760	5,787,199	6,558,693	9,508,001	12,061,702
California	90,620,644	93,219,149	100,791,369	101,013,199	98,198,538	137,284,754	175,401,518
Colorado	52,522,416	58,167,399	54,294,281	52,161,660	64,300,026	77,642,778	80,586,021
Connecticut	3,151,588	3,715,480	3,796,297	3,023,192	3,332,330	3,940,676	3,981,203
Delaware	491,657	425,360	541,542	288,516	282,292	336,172	523,991
District of Columbia	277,295	300,336	246,582	219,680	205,592	179,436	204,936
Florida	10,250,228	10,272,594	10,508,016	8,497,688	4,855,690	5,666,785	7,294,467
Georgia	6,172,857	6,306,140	6,525,792	5,704,856	5,094,688	6,779,828	7,650,553
Idaho	19,441,545	21,816,390	24,565,826	24,913,223	33,612,194	49,249,134	55,224,026
Illinois	106,275,115	122,986,424	131,701,551	117,005,441	114,112,315	146,359,792	236,934,229
Indiana	37,430,187	42,239,193	46,502,633	42,864,267	41,381,456	56,926,558	85,079,370
Iowa	21,112,896	22,900,350	25,602,015	26,287,115	27,048,177	30,210,284	39,336,372
Kansas	24,890,043	25,795,267	26,770,302	25,324,035	28,436,446	41,847,955	106,763,055
Kentucky	19,296,614	22,477,530	26,845,579	26,668,474	27,278,627	40,015,935	77,177,421
Louisiana	12,710,958	15,357,841	21,011,828	21,890,025	18,215,847	28,020,543	36,204,387
Maine	4,645,630	3,925,526	4,429,584	3,975,890	3,301,907	3,539,481	3,726,121
Maryland	9,386,515	10,851,671	11,292,723	10,587,564	10,581,224	13,335,013	19,617,596
Massachusetts	6,623,077	6,654,514	7,044,529	6,292,833	6,286,860	6,697,444	7,225,750
Michigan	65,275,324	80,062,486	72,143,211	57,743,555	93,938,255	140,666,124	163,997,853
Minnesota	53,395,881	66,672,729	85,814,533	45,680,865	62,391,440	113,662,522	152,490,554
Mississippi	1,052,842	1,242,528	1,143,472	1,104,197	666,143	890,566	966,135
Missouri	50,967,074	57,343,307	53,011,088	47,607,593	74,033,623	102,424,953	105,320,378
Montana	53,498,194	71,620,873	69,307,056	54,244,889	89,147,138	142,650,179	123,733,415
Nebraska	1,316,168	1,490,582	1,433,718	1,166,787	1,514,171	3,436,774	7,943,729
Nevada	34,501,832	39,111,828	37,842,084	29,984,338	35,991,891	53,510,559	55,410,190
New Hampshire	1,727,645	1,949,876	2,218,925	2,029,835	1,907,949	1,817,723	1,594,584
New Jersey	34,458,865	37,195,940	35,931,191	31,756,503	38,818,422	59,430,705	57,710,181
New Mexico	8,176,229	14,391,355	17,962,369	18,072,919	25,549,161	37,123,501	43,312,947
New York	34,317,594	38,431,910	41,709,002	36,420,134	36,414,038	45,619,119	52,123,552
North Carolina	2,793,825	3,368,923	3,739,696	3,519,245	3,365,805	4,595,551	5,246,391
North Dakota	957,425	1,025,741	1,065,676	1;063,540	985,885	1,283,809	1,749,549
Ohio	97,090,284	111,229,656	121,795,892	101,661,384	105,198,086	145,088,485	218,181,419
Oklahoma	43,036,253	53,614,130	80,168,820	78,744,447	83,672,991	169,556,331	259,134,377
Oregon	3,192,679	2,553,549	3,563,919	3,331,132	3,656,562	4,498,632	4,074,247
Pennsylvania	409,213,802	438,995,247	499,680,694	445,264,824	448,935,291	554,501,375	880,220,510
Rhode Island	1,253,656	942,842	813,952	777,716	855,007	789,208	717,123
South Carolina	1,803,579	1,606,989	1,464,150	1,414,294	1,129,709	1,392,073	1,393,297
South Dakota	8,047,259	8,436,240	7,909,059	7,861,601	8,093,670	8,696,680	8,348,684
Tennessee	17,899,882	19,362,209	21,008,938	19,647,145	22,166,494	28,277,365	36,910,448
Texas	18,798,837	22,797,015	31,666,910	30,363,426	29,220,951	47,711,571	77,552,369

Utah	43,774,331	51,004,942	53,606,520	45,636,198	62,586,261	99,734,209	113,589,282
Vermont	8,434,516	9,067,560	9,647,985	8,665,867	7,586,410	8,297,104	8,980,573
Virginia	13,713,566	14,969,922	17,167,620	16,400,347	16,994,786	20,560,956	32,243,648
Washington	15,865,277	15,347,313	17,579,743	13,830,739	11,455,715	14,521,014	18,576,052
West Virginia	101,932,248	123,847,812	143,591,272	133,633,229	136,070,173	187,043,011	306,916,191
Wisconsin	11,418,958	13,326,104	11,759,590	10,414,110	18,739,343	27,082,175	24,976,780
Wyoming	11,483,377	13,374,088	13,682,091	12,417,752	12,708,238	19,683,292	29,567,250

---

[a] In this table iron ore, not pig iron, is taken as the basis of valuation of iron, and in the case of other metals mine production (recoverable content of metals) is the basis.

Mineral production of Alabama in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Barytes....short tons..	7,631	$27,198	1,976	$8,808
Bauxite....long tons..	(a)	(a)	8,281	52,317
Cement....barrels..	1,442,575	1,410,104	1,329,833	1,494,879
Chert....short tons..			17,500	11,000
Clay products....		1,520,301		2,106,516
Clay, raw....short tons..	41,479	[b] 51,053	58,667	[b] 84,763
Coal....do....	18,086,197	24,859,831	20,068,074	45,616,992
Coke....do....	4,298,417	[b] 15,019,139	4,892,589	[b] 28,394,272
Ferroalloys....long tons..	9,943	(a b)	(a b)	(a b)
Gold....fine ounces (troy)..	418	8,650	109	2,262
Graphite, crystalline....pounds..	5,226,940	492,407	6,223,095	719,575
Iron ore....long tons..	6,801,839	10,843,231	7,101,586	13,049,535
Iron, pig....do....	2,672,498	[b] 38,994,660	2,971,626	[b] 64,309,714
Lime....short tons..	67,524	312,531	66,744	383,211
Manganese ore....long tons..	(a)	(a)	264	10,538
Mica....		5,615		3,808
Millstones....		(a)		(a)
Mineral waters....gallons sold..	103,944	12,174	56,270	5,509
Natural gas....		(a)		(a)
Potash (K_2O)....short tons..			2	748
Pyrite....long tons..			(a)	(a)
Sand and gravel....short tons..	726,650	184,216	476,678	222,011
Sand and sandstone (finely ground)....do....			(a)	(a)
Silver....fine ounces (troy)..	53	85	11	9
Stone....		1,202,256		1,611,497
Miscellaneous [c]....		1,529,744		4,504,428
Total value, eliminating duplications....		40,922,462		65,371,469

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.
[c] 1916: Bauxite, ferroalloys, manganese ore, millstones, and natural gas; 1917: Ferroalloys, millstones natural gas, pyrite, and sand and sandstone (finely ground).

Mineral production of Alaska in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore....short tons..	841	$10,306	84	$3,433
Chromic iron ore....long tons..			(a)	(a)
Coal....short tons..	13,073	52,317	53,955	265,317
Copper....pounds..	119,854,839	29,484,291	88,793,400	24,240,598
Gold....fine ounces (troy)..	834,068	17,241,713	709,049	14,657,353
Graphite, crystalline....pounds..			(a)	(a)
Gypsum....short tons..	(b)	(b)	(b)	(b)
Lead....do....	820	113,160	852	146,584
Petroleum....barrels..	(a)	(a)	(a)	(a)
Platinum....fine ounces (troy)..			76	7,845
Silver....do....	1,379,171	907,495	1,239,150	1,021,060
Stone....		(a)		(a)
Tin (metallic equivalent)....short tons..	139	120,874	100	123,300
Tungsten ore (60 per cent concentrates)...do....	47	69,518	32	45,000
Miscellaneous [c]....		521,839		200,165
Total value, eliminating duplications....		48,521,513		40,710,655

[a] Value included under "Miscellaneous."
[b] Calcined in Washington State. Value included under "Miscellaneous."
[c] 1916: Gypsum, petroleum, and stone; 1917: Chromic iron ore, crystalline graphite, gypsum, petroleum, and stone.

Mineral production of Arizona in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore ... short tons		$3		
Asbestos ... do	(a)	(a)	950	$481,490
Clay products		106,149		135,474
Clay, raw ... short tons			(a b)	(a b)
Copper ... pounds	721,833,169	177,570,960	712,166,891	194,421,561
Fluorspar ... short tons	(a)	(a)	(a)	(a)
Gems and precious stones		4,878		6,819
Gold ... fine ounces (troy)	192,801	3,985,559	245,174	5,068,193
Gypsum ... short tons	(a)	(a)	(a)	(a)
Lead ... do	13,531	1,867,284	11,733	2,018,028
Lime ... do	15,173	94,540	15,856	119,995
Manganese ore ... long tons	3,060	113,060	14,802	479,971
Manganiferous ore ... do	7,392	39,904	34,449	200,342
Molybdenum ... pounds	203,580	203,000	344,950	487,985
Quicksilver ... flasks	5	629	40	4,213
Sand and gravel ... short tons	(a)	(a)	17,268	5,799
Sand and sandstone (finely ground) ... do			(a)	(a)
Silica (quartz) ... do	(a)	(a)		
Silver ... fine ounces (troy)	7,212,039	4,745,522	6,983,913	5,754,744
Stone		306,579		319,724
Strontium ore ... short tons	(a)	(a)		
Sulphuric acid c ... do			(a)	(a)
Tungsten ore (60 per cent concentrates) ... do	218	385,292	150	173,700
Zinc ... do	9,839	2,636,845	10,447	2,131,276
Miscellaneous d		562,787		806,679
Total value, eliminating duplications		192,622,991		212,615,978

a Value included under "Miscellaneous."
b Value not included in total value for State.
c From copper smelting.
d 1916: Asbestos, fluorspar, gypsum, sand and gravel, silica (quartz), and strontium ore; 1917: Raw clay, fluorspar, gypsum, sand and sandstone (finely ground), and sulphuric acid from copper smelting.

Mineral production of Arkansas in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore ... short tons	250	$1,236		
Bauxite ... long tons	375,910	2,011,590	506,556	$2,724,007
Clay products		a 521,569		a 672,766
Clay, raw ... short tons	(b c)	(b c)		
Coal ... do	1,994,915	3,836,845	2,143,579	5,492,777
Fuller's earth ... do	(b)	(b)	(b)	(b)
Gems and precious stones		2,250		4,260
Iron ore: Sold to furnaces ... long tons			40	(b)
Iron ore: Sold for magnets ... do	5	(b)	5	(b)
Lead ... short tons	272	37,536	382	65,704
Lime ... do	19,199	102,683	17,350	117,593
Manganese ore ... long tons	6,318	180,722	10,140	448,511
Manganiferous ore ... do	3,682	22,665	9,100	83,227
Marl, calcareous ... short tons	(b)	(b)	(b)	(b)
Mineral waters ... gallons sold	1,152,505	100,616	1,020,463	78,141
Natural gas		210,964		315,612
Oilstones		(b)		(b)
Sand and gravel ... short tons	543,902	170,068	582,053	176,923
Stone		374,465		371,732
Zinc ... short tons	6,815	1,826,420	6,691	1,364,964
Miscellaneous d		118,183		145,485
Total value, eliminating duplications		9,508,001		12,061,702

a Exclusive of pottery, value for which is included under "Miscellaneous."
b Value included under "Miscellaneous."
c Value not included in total value for State.
d 1916: Pottery, raw clay, fuller's earth, iron ore, calcareous marl, and oilstones; 1917: Pottery, fuller's earth, iron ore, calcareous marl, and oilstones.

Mineral production of California in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore........short tons..	899	$6,159	42	$1,594
Asbestos........do....	(a)	(a)	(a)	(a)
Asphalt........do....	276,065	2,004,048	226,303	2,119,699
Barytes........do....	(a)	(a)	(a)	(a)
Borax (crude)........do....	103,525	2,409,459	108,875	3,609,632
Briquets (fuel)........do....	(a b)	(a b)	(a b)	(a b)
Calcium chloride........do....	....	....	(a)	(a)
Cement........barrels..	5,216,324	7,407,290	5,659,547	7,426,097
Chromic iron ore........long tons..	43,758	682,937	36,774	875,248
Clay products........	....	4,163,426	....	4,828,607
Clay, raw........short tons..	106,330	b 133,950	137,892	b 151,348
Coal........do....	(a)	(a)	(a)	(a)
Copper........pounds..	55,897,118	13,750,691	48,153,139	13,145,807
Diatomaceous earth........	....	(a)	....	(a)
Feldspar........short tons..	1,400	6,550	7,874	18,543
Ferroalloys........long tons..	(a b)	(a b)	2,113	b 544,650
Fuller's earth........short tons..	(a)	(a)	(a)	(a)
Gems and precious stones........	....	54,885	....	15,972
Gold........fine ounces (troy)..	1,035,745	21,410,741	971,733	20,087,504
Graphite, crystalline........pounds..	(a)	(a)	(a)	(a)
Gypsum........short tons..	32,575	109,061	30,552	96,718
Iron ore........long tons..	2,970	11,880	2,207	8,828
Iron, pig........do....	154	(a b)	....	....
Lead........short tons..	6,204	856,117	10,934	1,880,702
Lime........do....	56,820	393,930	78,401	597,528
Lithium minerals........do....	(a)	(a)	(a)	(a)
Magnesite........do....	154,259	1,388,331	211,663	2,116,630
Manganese ore........long tons..	6,136	122,592	14,196	328,501
Manganiferous ore........do....	139	(a)	152	1,760
Marl (calcareous)........short tons..	(a)	(a)	(a)	(a)
Mineral waters........gallons sold..	2,651,471	503,775	2,566,491	455,360
Molybdenum........pounds..	666	700	(a)	(a)
Natural gas........	....	5,440,277	....	6,816,524
Natural-gas gasoline........gallons..	17,158,754	2,293,822	28,817,604	4,438,022
Peat........short tons..	....	....	(a)	(a)
Pebbles for grinding........do....	6,000	36,000	9,278	48,775
Petroleum........barrels..	90,951,936	53,702,733	93,877,549	86,161,764
Platinum and allied metals.fine ounces (troy)..	687	55,979	297	29,014
Potash (K_2O)........short tons..	3,823	1,403,199	12,127	5,446,918
Pumice........do....	(a)	(a)	(a)	(a)
Pyrite........long tons..	145,762	565,699	115,817	333,501
Quicksilver........flasks..	21,045	2,649,355	23,938	2,521,151
Salt........short tons..	157,393	656,975	215,154	933,429
Sand and gravel........do....	4,489,498	1,036,085	3,781,388	1,138,128
Sand-lime brick........	....	c 3,337	....	(a)
Silica (quartz)........short tons..	5,648	11,533	7,325	18,197
Silver........fine ounces (troy)..	2,564,354	1,687,345	1,775,431	1,462,955
Slate........	....	(a)	....	(a)
Sodium salts (carbonate, bicarbonate, and sulphate) from natural sources........short tons..	10,666	528,696	20,713	891,997
Stone........	....	3,133,305	....	2,911,462
Strontium ore........short tons..	(a)	(a)	3,861	77,220
Sulphuric acid (60° Baumé) [d]........do....	(a)	(a)	(a)	(a)
Talc and soapstone........do....	685	10,969	4,152	74,000
Tungsten ore (60 per cent concentrates)..do....	2,171	4,098,999	2,781	3,010,300
Volcanic ash........	....	967	....	....
Zinc........short tons..	7,628	2,044,369	5,436	1,109,017
Miscellaneous [e]........	....	3,762,921	....	565,141
Total value, eliminating duplications....	....	137,284,754	....	175,401,518

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] Exclusive of fancy brick, value for which is included under "Miscellaneous."

[d] From copper smelting.

[e] 1916: Asbestos, barytes, fuel briquets, coal, diatomaceous earth, ferroalloys, fuller's earth, crystalline graphite, pig iron, lithium minerals, manganiferous ore, calcareous marl, pumice, fancy brick (sand-lime), slate, strontium ore, and sulphuric acid from copper smelting; 1917: Asbestos, barytes, fuel briquets, calcium chloride, coal, diatomaceous earth, fuller's earth, crystalline graphite, lithium minerals, calcareous marl, molybdenum peat, pumice, sand-lime brick, slate, and sulphuric acid from copper smelting.

Mineral production of Colorado in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asphalt........short tons..	(a)	(a)	700	$37,500
Barytes........do....	481	$3,005	....	....
Briquets (fuel)........do....	(a b)	(a b)	(a b)	(a b)
Cement........barrels..	(a)	(a)	(a)	(a)
Clay products........	....	1,930,039	....	2,579,267
Clay, raw........short tons..	76,986	[b] 77,830	106,775	[b] 103,376
Coal........do....	10,484,237	16,964,104	12,483,336	27,669,129
Coke........do....	1,053,553	[b] 3,736,467	1,112,449	[b] 5,479,734
Copper........pounds..	8,624,081	2,121,524	8,122,004	2,217,307
Ferroalloys........long tons..	(a b)	(a b)	30,415	[b] 1,614,701
Fluorspar........short tons..	(a)	(a)	17,104	196,633
Gems and precious stones........	....	10,818	....	7,205
Gold........fine ounces (troy)..	926,566	19,153,821	760,901	15,729,224
Graphite, amorphous........short tons..	(a)	(a)	(a)	(a)
Gypsum........do....	(a)	(a)	(a)	(a)
Iron ore........long tons..	(a)	(a)	(a)	(a)
Iron, pig........do....	367,629	(a b)	332,562	(a b)
Lead........short tons..	35,457	4,893,072	33,995	5,847,141
Lime........do....	5,479	36,473	6,212	54,676
Manganese ore........long tons..	110	1,670	114	(a)
Manganiferous ore........do....	107,113	318,027	124,861	303,802
Mica........	....	(a)	....	(a)
Mineral waters........gallons sold..	542,185	120,509	442,815	65,169
Molybdenum........pounds..	....	....	(a)	(a)
Natural gas........	....	(a)	....	(a)
Natural-gas gasoline........gallons..	(a)	(a)	(a)	(a)
Petroleum........barrels..	197,235	217,139	121,231	128,100
Potash (K_2O)........short tons..	....	....	(a)	(a)
Pyrite........long tons..	15,576	(a)	20,000	(a)
Sand and gravel........short tons..	244,208	93,259	150,063	74,540
Silica (quartz)........do....	(a)	(a)	....	....
Silver........fine ounces (troy)..	7,656,544	5,038,006	7,304,353	6,018,787
Stone........	....	975,794	....	823,904
Sulphur........long tons..	....	....	(a)	(a)
Sulphuric acid [c]........short tons..	(a)	(a)	(a)	(a)
Tungsten ore (60 per cent concentrates)..do....	2,401	4,666,301	2,707	2,994,000
Uranium and vanadium ores........do....	....	490,000	....	587,700
Zinc........do....	67,143	17,994,252	60,158	12,272,209
Miscellaneous [d]........	....	9,056,582	....	9,188,718
Total value, eliminating duplications....	....	77,642,778	....	80,586,021

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] From zinc smelting.

[d] 1916: Asphalt, fuel briquets, cement, ferroalloys, fluorspar, amorphous graphite, gypsum, iron ore, pig iron, mica, natural gas, natural-gas gasoline, pyrite, silica (quartz), and sulphuric acid from zinc smelting; 1917: Fuel briquets, cement, amorphous graphite, gypsum, iron ore, pig iron, manganese ore, mica, molybdenum, natural gas, natural-gas gasoline, potash, pyrite, sulphur, and sulphuric acid from zinc smelting.

Mineral production of Connecticut in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products		$1,865,329		$1,887,537
Clay, raw ... short tons	(a b)	(a b)	(a b)	(a b)
Diatomaceous earth		(a)		(a)
Feldspar ... short tons	12,333	76,979	10,937	73,932
Gems and precious stones		(a)		(a)
Iron ore ... long tons	(a)	(a)	(a)	(a)
Iron, pig ... do	4,978	(a b)	5,343	(a b)
Lime ... short tons	85,063	589,257	64,389	492,678
Mica		(a)		
Mineral waters ... gallons sold	2,837,878	133,768	1,964,096	103,978
Sand and gravel ... short tons	89,682	53,040	213,034	127,530
Sand-lime brick		(a)		
Silica (quartz) ... short tons	(a)	(a)		
Stone		1,143,011		1,238,684
Tungsten ore (60 per cent concentrates), ... short tons	3	8,400		
Miscellaneous c		235,348		243,997
Total value, eliminating duplications		3,940,676		3,981,203

a Value included under "Miscellaneous."

b Value not included in total value for State.

c 1916: Raw clay, diatomaceous earth, gems and precious stones, iron ore, pig iron, mica, sand-lime brick, and silica (quartz); 1917: Raw clay, diatomaceous earth, gems and precious stones, iron ore, and pig iron.

Mineral production of Delaware in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products		$187,388		$197,310
Clay, raw ... short tons	12,844	a 101,384	11,243	a 85,330
Mineral waters ... gallons sold	(b)	(b)	(b)	(b)
Sand and gravel ... short tons	9,487	9,721	166,413	101,252
Stone		121,354		216,346
Miscellaneous		17,709		9,083
Total value, eliminating duplications		336,172		523,991

a Value not included in total value for State.

b Value included under "Miscellaneous."

Mineral production of the District of Columbia in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products		a $129,394		$160,242
Mineral waters ... gallons sold	(b)	(b)	(b)	(b)
Sand-lime brick		(b)		(b)
Stone		3,315		4,615
Miscellaneous c		46,727		40,079
Total value, eliminating duplications		179,436		204,936

a Exclusive of pottery, value for which is included under "Miscellaneous."

b Value included under "Miscellaneous."

c 1916: Pottery, mineral waters, and sand-lime brick; 1917: Mineral waters and sand-lime brick.

Mineral production of Florida in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products		$226,362		$229,406
Clay, raw ... short tons	(a b)	(a b)	(a b)	(a b)
Flint lining for tube mills ... do			(a)	(a)
Fuller's earth ... do	(a)	(a)	(a)	(a)
Ilmenite ... do			(a)	(a)
Lime ... do	8,666	49,536	9,914	56,908
Mineral waters ... gallons sold	202,970	15,676	142,030	9,850
Monazite sand ... pounds	(a)	(a)		
Peat ... short tons	(a)	(a)	(a)	(a)
Phosphate rock ... long tons	1,515,845	4,170,165	2,022,599	5,464,493
Sand and gravel ... short tons	86,452	42,352	262,971	145,579
Sand-lime brick		90,794		95,158
Stone		479,837		654,845
Miscellaneous [c]		794,099		904,469
Total value, eliminating duplications		5,666,785		7,294,467

---

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Raw clay, fuller's earth, monazite sand, and peat; 1917: Raw clay, flint lining for tube mills, fuller's earth, ilmenite, and peat.

Mineral production of Georgia in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asbestos ... short tons	(a)	(a)	(a)	(a)
Barytes ... do	104,784	$401,295	111,300	$601,895
Bauxite ... long tons	40,388	239,089	52,901	337,498
Cement ... barrels	(a)	(a)	(a)	(a)
Clay products		2,361,982		2,426,671
Clay, raw ... short tons	193,791	[b]443,147	187,355	[b]599,359
Coal ... do	173,554	310,093	119,028	301,391
Coke ... do	47,127	[b]232,630	39,589	[b]322,175
Copper ... pounds	803,699	197,710	990,691	254,079
Feldspar ... short tons	(a)	(a)		
Fuller's earth ... do	(a)	(a)	(a)	(a)
Gold ... fine ounces (troy)	1,090	22,539	333	6,889
Iron ore: Sold to furnaces ... long tons	262,143	413,259	211,501	524,175
Iron ore: Sold for paint ... do			(a)	(a)
Iron, pig ... do			6,627	(a b)
Manganese ore ... do	(a)	(a)	3,614	89,888
Manganiferous ore ... do	(a)	(a)	13,281	118,368
Mica		2,094		13,541
Mineral waters ... gallons sold	618,367	45,210	411,127	37,441
Pyrite ... long tons	(a)	(a)	23,242	155,560
Sand and gravel ... short tons	483,615	126,799	380,154	138,182
Sand-lime brick		(a)		(a)
Silver ... fine ounces (troy)	74	49	46	37
Stone		1,799,210		1,797,098
Talc ... short tons	3,080	88,364	3,819	94,314
Miscellaneous [c]		772,135		998,526
Total value, eliminating duplications		6,779,828		7,650,553

---

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Asbestos, cement, feldspar, fuller's earth, manganese and manganiferous ores, pyrite, and sand-lime brick; 1917: Asbestos, cement, fuller's earth, iron ore sold for paint, pig iron, and sand-lime brick.

Mineral production of Idaho in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore......short tons..	259	$2,946	39	$1,715
Asbestos......do....	(a)	(a)	(a)	(a)
Clay products......		(a)		(a)
Clay, raw......short tons..	(ab)	(ab)	(ab)	(ab)
Coal......do....	(a)	(a)	(a)	(a)
Copper......pounds..	8,478,281	2,085,657	7,827,574	2,136,928
Gems and precious stones......		(a)		(a)
Gold......fine ounces (troy)..	53,977	1,115,810	38,933	804,809
Lead......short tons..	187,541	25,880,643	196,780	33,846,119
Lime......do....	4,389	31,786	7,228	62,331
Mica......		(a)		(a)
Phosphate rock......long tons..			(a)	(a)
Quicksilver......flasks..			5	526
Salt......short tons..	44	511	16	216
Sand and gravel......do....	(a)	(a)	(a)	(a)
Sand-lime brick......		(a)		(a)
Silver......fine ounces (troy)..	12,300,873	8,093,974	12,029,338	9,912,175
Stone......		96,382		94,644
Tungsten ore (60 per cent concentrates), ...short tons..	101	113,470	2	1,933
Zinc......do....	43,253	11,591,699	39,927	8,145,122
Miscellaneous [c]......		237,460		219,248
Total value, eliminating duplications....		49,249,134		55,224,026

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Asbestos, clay products, raw clay, coal, gems and precious stones, mica, sand and gravel, and sand-lime brick; 1917: Asbestos, clay products, raw clay, coal, gems and precious stones, mica, phosphate rock, sand and gravel, and sand-lime brick.

Mineral production of Illinois in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asphalt......short tons..	155,406	$1,285,470	110,756	$1,317,855
Cement......barrels..	[a]3,562,659	[a]3,386,431	[a]4,378,233	[a]6,090,158
Clay products......		17,633,351		19,565,420
Clay, raw......short tons..	197,701	[b]378,440	195,693	[b]789,589
Coal......do....	66,195,336	82,457,954	86,199,387	162,281,822
Coke......do....	2,320,400	[b]10,619,066	2,289,833	[b]14,455,539
Ferroalloys......long tons..	(bc)	(bc)	(bc)	(bc)
Fluorspar......short tons..	(c)	(c)	156,676	1,373,333
Iron, pig......long tons..	3,857,391	[b]67,764,309	3,458,126	[b]91,094,541
Lead......short tons..	1,072	147,936	1,439	247,508
Lime......do....	80,012	369,038	83,409	501,320
Mineral paints (zinc and lead pigments)..do....	(bc)	(bc)	(bc)	(bc)
Mineral waters......gallons sold..	1,777,741	94,056	1,370,461	66,042
Natural gas......		396,357		479,072
Natural-gas gasoline......gallons..	2,260,288	262,664	4,934,099	866,033
Peat......short tons..	(c)	(c)	(c)	(c)
Petroleum......barrels..	17,714,235	29,237,168	15,776,860	31,358,069
Potash (K_2O)......short tons..			(c)	(c)
Pyrite......long tons..	20,482	51,432	24,596	89,998
Sand and gravel......short tons..	8,365,225	2,587,437	9,120,698	3,658,799
Sand and sandstone (finely ground)......do....	(c)	(c)	386,866	630,256
Sand-lime brick......		(c)		
Silver......fine ounces (troy)..	5,684	3,740	7,186	5,921
Stone......		3,403,094		3,322,041
Sulphuric acid [d]......short tons..		2,999,548		3,902,831
Tripoli......		82,968		31,338
Zinc......short tons..	3,404	912,272	4,267	870,468
Miscellaneous [e]......		5,559,903		6,343,662
Total value, eliminating duplications....		146,359,792		236,934,229

[a] Exclusive of natural cement, value for which is included under "Miscellaneous."

[b] Value not included in total value for State.

[c] Value included under "Miscellaneous."

[d] From zinc smelting.

[e] 1916: Natural cement, ferroalloys, fluorspar, zinc and lead pigments, peat, sand and sandstone (finely ground), and sand-lime brick; 1917: Natural cement, ferroalloys, zinc and lead pigments, peat, and potash.

Mineral production of Indiana in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Cement....barrels..	[a] 10,350,105	[a] $11,487,893	[a] 8,148,678	[a] $11,084,930
Clay products....	....	9,667,313	....	10,999,474
Clay, raw....short tons..	69,748	[b] 65,537	73,863	[b] 78,463
Coal....do....	20,093,528	25,506,246	26,539,329	52,940,106
Coke....do....	3,489,660	[b] 16,096,479	3,540,718	[b] 21,831,302
Gems and precious stones....	....	(c)	....	....
Iron, pig....long tons..	1,735,428	(bc)	2,162,872	(bc)
Lime....short tons..	121,306	495,283	118,530	646,555
Mineral waters....gallons sold..	609,544	188,645	521,758	152,469
Natural gas....	....	503,373	....	453,310
Oilstones and scythestones....	....	25,521	....	27,693
Peat....short tons..	(c)	(c)	(c)	(c)
Petroleum....barrels..	769,036	1,207,565	759,432	1,470,548
Pyrite....long tons..	772	2,445	(c)	(c)
Sand and gravel....short tons..	8,165,989	1,879,073	5,906,196	1,591,158
Sand-lime brick....	....	54,148	....	60,201
Stone....	....	4,657,813	....	4,449,809
Sulphuric acid [d]....short tons..	(c)	(c)	(c)	(c)
Miscellaneous [e]....	....	27,482,752	....	51,582,551
Total value, eliminating duplications....	....	56,926,558	....	85,079,370

[a] Exclusive of natural cement, value for which is included under "Miscellaneous."
[b] Value not included in total value for State.
[c] Value included under "Miscellaneous."
[d] From zinc smelting.
[e] 1916: Natural cement, gems and precious stones, pig iron, peat, and sulphuric acid from zinc smelting; 1917: Natural cement, pig iron, peat, pyrite, and sulphuric acid from zinc smelting.

Mineral production of Iowa in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Cement....barrels..	4,853,789	$6,165,547	4,428,765	$6,870,863
Clay products....	....	[a] 7,379,289	....	7,540,213
Clay, raw....short tons..	21,829	[b] 2,427	5,488	[b] 3,012
Coal....do....	7,260,800	13,530,383	8,965,830	21,096,408
Ferroalloys....long tons..	950	(bc)	(bc)	(bc)
Gypsum....short tons..	522,293	1,496,795	461,864	2,041,997
Iron ore....long tons..	10,151	(c)	22,612	(c)
Lead....short tons..	14	1,932	34	5,848
Lime....do....	(c)	(c)	(c)	(c)
Mineral waters....gallons sold..	148,732	14,404	99,103	12,125
Natural gas....	....	275	....	225
Sand and gravel....short tons..	3,321,691	980,272	2,909,441	1,060,586
Stone....	....	561,084	....	520,083
Zinc....short tons..	21	5,628	18	3,672
Miscellaneous [d]....	....	157,325	....	539,662
Total value, eliminating duplications....	....	30,210,284	....	39,336,372

[a] Exclusive of pottery, value for which is included under "Miscellaneous."
[b] Value not included in total value for State.
[c] Value included under "Miscellaneous."
[d] 1916: Pottery, ferroalloys, iron ore, and lime; 1917: Ferroalloys, iron ore, and lime.

Mineral production of Kansas in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asphalt..........short tons..	(a)	(a)	(a)	(a)
Cement..........barrels..	[b] 4,298,097	[b] $4,613,609	[b] 3,772,884	[b] $5,271,721
Clay products..........		2,747,803		2,695,722
Coal..........short tons..	6,881,455	12,252,723	7,184,975	16,618,277
Gems and precious stones..........		(a)		
Gypsum..........short tons..	78,257	322,785	79,331	424,611
Lead..........do....	1,648	227,424	3,025	520,300
Lime..........do....	(a)	(a)		
Mineral paints (zinc and lead pigments)..do....	(a c)	(a c)	(a c)	(a c)
Mineral waters..........gallons sold..	237,790	58,792	289,493	67,776
Natural gas..........		4,855,389		5,701,436
Natural-gas gasoline..........gallons..	215,000	35,030	1,174,980	241,219
Petroleum..........barrels..	8,738,077	10,339,958	36,536,125	67,120,573
Pumice..........short tons..	23,804	51,648	(a)	(a)
Salt..........do....	639,071	1,302,359	746,976	2,027,466
Sand and gravel..........do....	1,164,995	303,630	823,403	195,578
Stone..........		603,490		673,831
Sulphuric acid (60° Baumé)[d]..........short tons..	(a)	(a)	(a)	(a)
Zinc..........do....	12,448	3,336,064	20,249	4,130,796
Miscellaneous[e]..........		1,717,111		2,285,603
Total value, eliminating duplications....		41,847,955		106,763,055

---

[a] Value included under "Miscellaneous."

[b] Exclusive of natural cement, value for which is included under "Miscellaneous."

[c] Value not included in total value for State.

[d] From zinc smelting.

[e] 1916: Asphalt, natural cement, gems and precious stones, lime, zinc and lead pigments, and sulphuric acid from zinc smelting; 1917: Asphalt, natural cement, zinc and lead pigments, pumice, and sulphuric acid from zinc smelting.

Mineral production of Kentucky in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asphalt..........short tons..	(a)	(a)	(a)	(a)
Barytes..........do....	11,068	$54,995	6,720	$36,084
Cement..........barrels..	(a)	(a)	(a)	(a)
Clay products..........		3,559,257		5,040,255
Clay, raw..........short tons..	62,247	[b] 170,984	91,727	[b] 320,365
Coal..........do....	25,393,997	30,193,047	27,807,971	60,297,653
Coke..........do....	802,526	[b] 2,225,186	863,071	[b] 4,119,263
Ferroalloys..........long tons..	40,431	(a b)	(a b)	(a b)
Fluorspar..........short tons..	(a)	(a)	43,639	697,566
Iron, pig..........long tons..	144,444	[b] 2,595,600	192,204	[b] 5,532,367
Lead..........short tons..	153	21,114	123	21,156
Lime..........do....	1,236	6,304	723	3,783
Lithographic stone..........do....	20	1,500	3	489
Mineral waters..........gallons sold..	377,246	52,305	301,748	40,189
Natural gas..........		752,635		580,380
Natural-gas gasoline..........gallons..	725,467	141,347	3,818,209	763,186
Oilstones..........		(a)		(a)
Petroleum..........barrels..	1,202,569	2,188,495	3,088,160	7,033,714
Phosphate rock..........long tons..	(a)	(a)	(a)	(a)
Pyrite..........do....			(a)	(a)
Sand and gravel..........short tons..	1,053,431	474,216	905,414	490,546
Sand-lime brick..........		(a)		(a)
Stone..........		1,429,838		1,118,434
Zinc..........short tons..	1,096	293,728	751	153,204
Miscellaneous[c]..........		1,668,158		1,698,558
Total value, eliminating duplications....		40,015,935		77,177,421

---

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Asphalt, cement, ferroalloys, fluorspar, oilstones, phosphate rock, and sand-lime brick; 1917; Asphalt, cement, ferroalloys, oilstones, phosphate rock, pyrite, and sand-lime brick.

Mineral production of Louisiana in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asphalt....short tons..			(a)	(a)
Clay products....		b $360,855		$447,941
Mineral waters....gallons sold..	429,650	31,068	270,000	19,490
Natural gas....		2,660,445		3,262,987
Natural-gas gasoline....gallons..	2,113,159	269,564	4,979,754	814,747
Petroleum....barrels..	15,248,138	14,669,774	11,392,201	17,224,602
Potash (K_2O)....short tons..	(a)	(a)	(a)	(a)
Salt....do....	(a)	(a)	(a)	(a)
Sand and gravel....do....	1,579,701	535,968	1,514,522	639,807
Sand-lime brick....				(a)
Stone....		(a)		(a)
Sulphur....long tons..	(a)	(a)	(a)	(a)
Miscellaneous c....		9,492,869		13,794,813
Total value, eliminating duplications....		28,020,543		36,204,387

[a] Value included under "Miscellaneous."

[b] Exclusive of pottery, value for which is included under "Miscellaneous."

[c] 1916: Pottery, potash, salt, stone, and sulphur; 1917: Asphalt, potash, salt, sand-lime brick, stone, and sulphur.

Mineral production of Maine in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products....		a $546,725		a $531,870
Copper....pounds..			30,406	8,301
Feldspar....short tons..	28,006	235,922	35,527	291,252
Gems and precious stones....		8,458		10,870
Lime....short tons..	162,100	956,371	124,199	950,811
Magnesium....pounds..	(b c)	(b c)	(b c)	(b c)
Mineral waters....gallons sold..	1,038,861	353,792	1,014,084	343,587
Peat....short tons..	(b)	(b)		
Potash (K_2O)....do....	(b)	(b)		
Sand and gravel....do....	(b)	(b)	8,169	7,358
Silica (quartz)....do....			(b)	(b)
Slate....		(b)		(b)
Stone....		1,068,485		1,254,637
Miscellaneous d....		405,747		389,061
Total value, eliminating duplications....		3,539,481		3,726,121

[a] Exclusive of pottery, value for which is included under "Miscellaneous."

[b] Value included under "Miscellaneous."

[c] Value not included in total value for State.

[d] 1916: Pottery, magnesium, peat, potash, sand and gravel, and slate; 1917: Pottery, magnesium, silica (quartz), and slate.

Mineral production of Maryland in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asbestos.....short tons..			(a)	(a)
Briquets, fuel.....do....	(a b)	(a b)		
Cement.....barrels..	(a)	(a)	(a)	(a)
Chromic iron ore.....long tons..	(a)	(a)	(a)	(a)
Clay products.....		$1,825,870		$2,468,138
Clay, raw.....short tons..	45,975	[b]82,667	42,364	[b]114,027
Coal.....do....	4,460,046	6,947,623	4,745,924	11,667,852
Coke.....do....	489,982	[b]1,387,009	518,810	[b]3,925,418
Copper.....pounds..	158,780	39,060	291,501	79,580
Diatomaceous earth.....		(a)		(a)
Feldspar.....short tons..	23,928	83,957	15,779	56,958
Ferroalloys.....long tons..	(a b)	(a b)	33,097	[b]4,448,031
Gold.....fine ounces (troy)..			3	66
Iron ore.....long tons..	(a)	(a)	10,730	40,423
Iron, pig.....do....	465,865	(a b)	398,813	(a b)
Lime.....short tons..	157,673	574,998	133,087	694,576
Mineral waters.....gallons sold..	1,312,788	99,020	1,036,045	86,938
Potash (K_2O).....short tons..	(a)	(a)	792	341,885
Sand and gravel.....do....	1,872,159	900,061	1,727,440	923,463
Silica (quartz).....do....	7,208	31,712	3,251	22,633
Silver.....fine ounces (troy)..	575	378	1,092	900
Slate.....		71,737		67,938
Stone.....		921,909		938,637
Talc and soapstone.....short tons..	(a)	(a)	(a)	(a)
Miscellaneous [c].....		15,519,309		11,740,502
Total value, eliminating duplications.....		13,335,013		19,617,596

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Fuel briquets, cement, chromic iron ore, diatomaceous earth, ferroalloys, iron ore, pig iron, potash, and talc and soapstone; 1917: Asbestos, cement, chromic iron ore, diatomaceous earth, pig iron, and talc and soapstone.

Mineral production of Massachusetts in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products.....		$1,892,558		$1,971,980
Clay, raw.....short tons..	892	[a]1,296	847	[a]1,329
Coke.....do....	563,048	(a b)	595,113	(a b)
Diatomaceous earth.....		(b)		
Fuller's earth.....short tons..	(b)	(b)	(b)	(b)
Gems and precious stones.....		(b)		(b)
Iron ore.....long tons..	(b)	(b)	11,019	(b)
Iron, pig.....do....	(a b)	(a b)	5,061	(a b)
Lime.....short tons..	145,020	811,402	134,937	916,569
Mineral waters.....gallons sold..	3,124,096	128,478	2,908,638	139,075
Peat.....short tons..	(b)	(b)	(b)	(b)
Potash (K_2O).....do....	(b)	(b)	(b)	(b)
Sand and gravel.....do....	1,049,577	533,308	1,005,952	694,960
Sand-lime brick.....		110,333		127,695
Silica (quartz).....short tons..	(b)	(b)	(b)	(b)
Stone.....		3,138,165		3,113,423
Talc.....short tons..	(b)	(b)	(b)	(b)
Miscellaneous [c].....		2,359,380		4,279,961
Total value, eliminating duplications.....		6,697,444		7,225,750

[a] Value not included in total value for State.

[b] Value included under "Miscellaneous."

[c] 1916: Coke, diatomaceous earth, fuller's earth, gems and precious stones, iron ore, pig iron, peat, potash, silica (quartz), and talc; 1917: Coke, fuller's earth, gems and precious stones, iron ore, pig iron, peat, potash, silica (quartz), and talc.

Mineral production of Michigan in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Briquets, fuel...short tons	(a b)	(a b)		
Bromine...pounds	513,208	$685,445	735,654	$405,059
Calcium chloride...short tons	17,122	159,358	22,679	294,698
Cement...barrels	5,151,818	6,017,911	4,313,771	6,122,887
Clay products		3,497,770		4,034,245
Clay, raw...short tons	3,454	[b]11,153	5,746	[b]13,627
Coal...do	1,180,360	2,653,182	1,374,805	4,426,314
Coke...do	(a b)	(a b)	(a b)	(a b)
Copper...pounds	273,692,525	67,328,361	255,710,128	69,808,865
Gems and precious stones		113		95
Graphite, amorphous...short tons	(a)	(a)	(a)	(a)
Grindstones		(a)		(a)
Gypsum...short tons	457,375	1,066,599	375,803	1,568,655
Iron ore:				
Sold to furnaces...long tons	18,995,797	49,054,340	17,712,916	62,833,624
Sold for paint...do	2,358	(a)	1,445	(a)
Iron, pig...do	505,646	[b]8,851,361	611,446	[b]18,300,501
Lime...short tons	86,447	385,341	135,920	892,682
Magnesium...pounds			(a)	(a)
Manganiferous ore...long tons			52,198	(a)
Mineral waters...gallons sold	996,875	108,867	1,069,164	105,641
Natural gas		948		1,013
Petroleum...barrels	(a)	(a)	(a)	(a)
Potash (K_2O)...short tons	314	207,175	381	299,395
Salt...do	2,088,559	4,612,567	2,250,939	6,877,202
Sand and gravel...do	4,407,475	1,306,256	3,814,445	1,641,748
Sand-lime brick		499,711		370,723
Scythestones		(a)		(a)
Silica (quartz)...short tons	(a)	(a)	(a)	(a)
Silver...fine ounces (troy)	716,640	471,549	688,551	567,366
Stone		2,494,284		3,423,825
Miscellaneous [c]		3,207,501		5,791,496
Total value, eliminating duplications		140,666,124		163,997,853

---

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Fuel briquets, coke, amorphous graphite, grindstones, iron ore sold for paint, petroleum, scythestones, and silica (quartz); 1917: Coke, amorphous graphite, grindstones, iron ore sold for paint, magnesium, manganiferous ore, petroleum, scythestones, and silica (quartz).

Mineral production of Minnesota in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Cement...barrels	868,300	$911,705	1,552,250	$2,143,671
Clay products		[a] 2,064,362		[a] 2,197,664
Clay, raw...short tons	(b c)	(b c)	(b c)	(b c)
Coke...do	431,319	[c] 1,968,675	490,272	[c] 3,468,355
Flint lining for tube mills...do			(b)	(b)
Gems and precious stones		(b)		(b)
Iron ore...long tons	45,869,251	106,628,784	44,962,127	142,901,148
Iron, pig...do	377,132	(b c)	363,180	(b c)
Lime...short tons	20,150	103,000	18,072	119,704
Manganiferous ore...long tons	240,403	790,762	451,163	2,055,335
Mineral waters...gallons sold	4,188,434	145,582	3,004,546	109,964
Pebbles for grinding...short tons			(b)	(b)
Sand and gravel...do	1,468,530	491,270	1,209,455	488,069
Sand-lime brick		178,828		152,531
Stone		1,833,800		1,711,318
Miscellaneous [d]		6,210,674		9,993,125
Total value, eliminating duplications		113,662,522		152,490,554

---

[a] Exclusive of pottery, value for which is included under "Miscellaneous."

[b] Value included under "Miscellaneous."

[c] Value not included in total value for State.

[d] 1916: Pottery, raw clay, gems and precious stones, and pig iron; 1917: Pottery, raw clay, flint lining for tube mills, gems and precious stones, pig iron, and pebbles for grinding.

Mineral production of Mississippi in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products		$520,618		$553,585
Clay, raw ... short tons	(a b)	(a b)	(a b)	(a b)
Mineral waters ... gallons sold	399,248	48,439	197,555	49,786
Sand and gravel ... short tons	1,435,460	321,509	1,414,048	360,664
Stone				(a)
Miscellaneous [c]		100		51,000
Total value, eliminating duplications		890,566		966,135

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.

Mineral production of Missouri in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Barytes ... short tons	58,223	$365,111	59,046	$391,363
Briquets, fuel ... do	(a b)	(a b)	(a b)	(a b)
Cement ... barrels	5,732,001	6,333,567	5,800,988	8,248,007
Chats ... short tons	2,890,970	433,646	1,426,716	285,343
Clay products		7,640,995		10,339,049
Clay, raw ... short tons	439,583	[b] 988,884	497,267	[b] 1,386,338
Coal ... do	4,742,146	9,044,505	5,670,549	13,755,864
Coke ... do	(a b)	(a b)	(a b)	(a b)
Copper ... pounds	386,200	95,005	365,013	99,649
Gems and precious stones		(a)		
Iron ore ... long tons	34,914	116,484	38,770	134,906
Iron, pig ... do	39,018	(a b)	83,266	(a b)
Lead ... short tons	233,088	32,166,144	234,156	40,274,832
Lime ... do	199,260	956,300	234,936	1,435,914
Mineral paints (zinc and lead pigments) ... do	(a b)	(a b)	(a b)	(a b)
Mineral waters ... gallons sold	1,394,092	109,814	401,776	57,175
Natural gas		17,594		8,230
Petroleum ... barrels	(a)	(a)		
Potash (K_2O) ... short tons	(a)	(a)		
Pyrite ... long tons	(a)	(a)	(a)	(a)
Sand and gravel ... short tons	3,643,205	877,634	2,274,072	1,101,745
Silver ... fine ounces (troy)	129,450	85,178	61,586	50,747
Stone		2,242,742		1,983,300
Tripoli		[c] 92,248		[c] 16,606
Tungsten ore (60 per cent concentrates) ... short tons	5	2,657		
Zinc ... do	155,960	41,797,280	132,918	27,115,272
Miscellaneous [d]		3,141,535		5,630,279
Total value, eliminating duplications		102,424,953		105,320,378

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.
[c] Includes small product from Oklahoma. Not separable.
[d] 1916: Fuel briquets, coke, gems and precious stones, pig iron, zinc and lead pigments, petroleum, potash, and pyrite; 1917: Fuel briquets, coke, pig iron, zinc and lead pigments, and pyrite.

Mineral production of Montana in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Cement ... barrels	(a)	(a)	(a)	(a)
Clay products	...	b $717,551	...	$663,815
Clay, raw ... short tons	(a c)	(a c)	7,083	c 26,710
Coal ... do	3,632,527	6,286,197	4,226,689	8,919,136
Copper ... pounds	352,928,373	86,820,360	274,462,574	74,928,283
Gems and precious stones	...	108,263	...	59,130
Gold ... fine ounces (troy)	220,130	4,550,494	170,147	3,517,253
Graphite, crystalline ... pounds	(a)	(a)	(a)	(a)
Gypsum ... short tons	(a)	(a)	(a)	(a)
Iron ore ... long tons	...	...	(a)	(a)
Lead ... short tons	6,798	938,064	10,976	1,887,805
Lime ... do	(a)	(a)	5,281	35,512
Manganese ore ... long tons	6,418	37,978	61,109	1,797,842
Manganiferous ore ... do	...	...	1,568	(a)
Mineral waters ... gallons sold	181,800	12,294	211,183	9,570
Natural gas	...	38,856	...	81,406
Petroleum ... barrels	44,917	44,019	99,399	146,272
Sand and gravel ... short tons	296,737	58,185	597,642	139,384
Silver ... fine ounces (troy)	16,494,366	10,853,293	13,128,142	10,817,589
Stone	...	261,460	...	255,835
Sulphuric acid (60° Baumé) [d] ... short tons	(a)	(a)	(a)	(a)
Tungsten ore (60 per cent concentrates) ... do	1	1,163	16	21,500
Zinc ... do	114,630	30,720,716	93,130	18,998,452
Miscellaneous [e]	...	1,221,380	...	1,454,631
Total value, eliminating duplications	...	142,650,179	...	123,733,415

[a] Value included under "Miscellaneous."
[b] Exclusive of pottery, value for which is included under "Miscellaneous."
[c] Value not included in total value for State.
[d] From copper smelting.
[e] 1916: Cement, pottery, raw clay, crystalline graphite, gypsum, lime, and sulphuric acid from copper smelting; 1917: Cement, crystalline graphite, gypsum, iron ore, manganiferous ore, and sulphuric acid from copper smelting.

Mineral production of Nebraska in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Cement ... barrels	...	...	(a)	(a)
Clay products	...	b $943,553	...	b $1,160,508
Clay, raw ... short tons	(a c)	(a c)	1,980	c 4,412
Mineral waters ... gallons sold	8,440	946	(a)	(a)
Potash (K_2O) ... short tons	(a)	(a)	14,558	5,879,534
Pumice ... do	9,259	25,155	5,051	16,707
Sand and gravel ... do	1,267,998	289,872	1,327,152	358,414
Stone	...	406,707	...	476,307
Miscellaneous [d]	...	1,772,522	...	52,259
Total value, eliminating duplications	...	3,436,774	...	7,943,729

[a] Value included under "Miscellaneous."
[b] Exclusive of pottery, value for which is included under "Miscellaneous."
[c] Value not included in total value for State.
[d] 1916: Pottery, raw clay, and potash; 1917: Cement, pottery, and mineral waters.

Mineral production of Nevada in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore........short tons..	1,400	$13,216	872	$46,609
Barytes........do....	(a)	(a)	(a)	(a)
Clay products........	....	(a)	....	(a)
Clay, raw........short tons..	....	....	(a b)	(a b)
Copper........pounds..	105,116,813	25,858,736	122,794,704	33,522,954
Diatomaceous earth........	....	(a)	....	(a)
Gems and precious stones........	....	15,734	....	17,851
Gold........fine ounces (troy)..	428,904	8,866,237	336,664	6,959,468
Graphite, amorphous........short tons..	(a)	(a)	(a)	(a)
Gypsum........do....	(a)	(a)	(a)	(a)
Iron ore........long tons..	9,910	(a)	1,010	(a)
Lead........short tons..	12,819	1,768,972	13,839	2,380,302
Lime........do....	(a)	(a)	(a)	(a)
Manganese ore........long tons..	(a)	(a)	3,450	91,907
Manganiferous ore........do....	122,429	(a)	122,872	142,543
Mineral waters........gallons sold..	346,260	4,160	(a)	(a)
Molybdenum........pounds..	....	....	(a)	(a)
Pebbles for grinding........short tons..	(a)	(a)	(a)	(a)
Platinum and allied metals..fine ounces (troy)..	(a)	(a)	507	55,021
Quicksilver........flasks..	2,198	276,706	997	105,004
Salt........short tons..	(a)	(a)	(a)	(a)
Sand and gravel........do....	(a)	(a)	75,466	8,813
Silver........fine ounces (troy)..	13,837,525	9,105,092	11,269,969	9,286,454
Stone........	....	....	....	31,625
Sulphur........long tons..	(a)	(a)	(a)	(a)
Tungsten ore (60 per cent concentrates), ...short tons..	689	2,240,619	143	187,500
Zinc........do....	16,222	4,347,387	11,154	2,275,402
Miscellaneous [c]........	....	1,013,700	....	299,757
Total value, eliminating duplications....	....	53,510,559	....	55,410,190

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.
[c] 1916: Barytes, clay products, diatomaceous earth, amorphous graphite, gypsum, iron ore, lime, manganese and manganiferous ores, pebbles for grinding, platinum and allied metals, salt, sand and gravel, and sulphur; 1917: Barytes, clay products, raw clay, diatomaceous earth, amorphous graphite, gypsum, iron ore, lime, mineral waters, molybdenum, pebbles for grinding, salt, and sulphur.

Mineral production of New Hampshire in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products........	....	[a] $473,434	....	[a] $411,876
Diatomaceous earth........	....	(b)	....	....
Feldspar........short tons..	(b)	(b)	(b)	(b)
Fluorspar........do....	(b)	(b)	(b)	(b)
Garnet, abrasive........do....	(b)	(b)	(b)	(b)
Gems and precious stones........	....	550	....	(b)
Lead........short tons..	47	6,433	48	8,256
Mica........	....	75,239	....	169,051
Mineral waters........gallons sold..	269,860	14,935	105,181	6,975
Sand and gravel........short tons..	(b)	(b)	258,638	28,070
Scythestones........	....	(b)	....	(b)
Silver........fine ounces (troy)..	945	622	120	99
Stone........	....	1,141,810	....	921,943
Zinc........short tons..	36	9,681	45	9,190
Miscellaneous [c]........	....	95,019	....	39,124
Total value, eliminating duplications....	....	1,817,723	....	1,594,584

[a] Exclusive of pottery, value for which is included under "Miscellaneous."
[b] Value included under "Miscellaneous."
[c] 1916: Pottery, diatomaceous earth, feldspar, fluorspar, abrasive garnet, sand and gravel, and scythestones; 1917: Pottery, feldspar, fluorspar, abrasive garnet, gems and precious stones, and scythestones.

Mineral production of New Jersey in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Briquets, fuel......short tons..	(a b)	(a b)	....	....
Cement......barrels..	2,592,302	$2,534,623	2,397,069	$2,962,592
Clay products......	....	20,814,402	....	22,529,232
Clay, raw......short tons..	371,916	[b] 790,796	380,362	[b] 1,035,703
Coke......do....	210,766	(a b)	423,361	(a b)
Ferroalloys......long tons..	....	....	6,228	(a b)
Gems and precious stones......	....	....	....	(a)
Iron ore......long tons..	528,084	1,877,056	474,708	2,341,160
Iron, pig......do....	75,433	(a b)	187,753	[b] 6,618,536
Lime......short tons..	7,110	26,084	5,002	18,978
Manganiferous zinc residuum [c]......long tons..	198,817	(a)	155,832	(a)
Marl, greensand......short tons..	1,220	610	(a)	(a)
Mineral paints (zinc and lead pigments)..do....	....	....	(a b)	(a b)
Mineral waters......gallons sold..	1,580,028	130,993	1,283,157	115,188
Peat......short tons..	25,864	197,754	42,361	320,550
Potash (K_2O)......do....	(a)	(a)	....	....
Sand and gravel......do....	3,936,020	1,517,473	3,782,457	2,025,324
Sand and sandstone (finely ground)......do....	....	....	(a)	(a)
Sand-lime brick......	....	(a)	....	....
Slate......	....	(a)	....	(a)
Stone......	....	1,655,692	....	1,860,397
Sulphuric acid [d]......short tons..	....	....	....	(a)
Talc......do....	(a)	(a)	(a)	(a)
Zinc......do....	112,020	(a)	120,846	(a)
Miscellaneous [e]......	....	34,658,439	....	30,022,147
Total value, eliminating duplications....	....	59,430,705	....	57,710,181

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] Ore mined in New Jersey; smelted in Pennsylvania.

[d] From copper smelting.

[e] 1916: Fuel briquets, coke, pig iron, manganiferous zinc residuum, potash, sand-lime brick, slate, talc, and zinc; 1917: Coke, ferroalloys, gems and precious stones, greensand marl, zinc and lead pigments, sand and sandstone (finely ground), slate, sulphuric acid from copper smelting, talc, and zinc.

Mineral production of New Mexico in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products......	....	$257,561	....	$257,875
Clay, raw......short tons..	3,602	[a] 9,511	2,269	[a] 8,931
Coal......do....	3,793,011	5,580,369	4,000,527	7,455,166
Coke......do....	502,812	[a] 1,718,976	577,679	[a] 2,805,277
Copper......pounds..	92,747,289	22,815,833	105,568,000	28,820,064
Gems and precious stones......	....	675	....	(b)
Gold......fine ounces (troy)..	66,877	1,382,480	51,479	1,064,158
Gypsum......short tons..	(b)	(b)	(b	(b)
Iron ore......long tons..	157,779	168,157	231,604	381,275
Lead......short tons..	4,107	566,779	4,554	783,357
Lime......do....	1,582	11,670	1,829	12,327
Manganese ore......long tons..	(b)	(b)	2,603	54,143
Manganiferous ore......do....	16,068	(b)	15,900	(b)
Mineral paints (zinc and lead pigments), ...short tons..	....	....	(a b)	(a b)
Mineral waters......gallons sold..	35,450	3,965	48,325	2,330
Salt......short tons..	(b)	(b)	(b)	(b)
Sand and gravel......do....	(b)	(b)	(b)	(b)
Silver......fine ounces (troy)..	1,766,274	1,162,208	1,394,365	1,148,957
Stone......	....	77,290	....	72,411
Tungsten ore (60 per cent concentrates), ...short tons..	16	39,227	(b)	(b)
Zinc......do....	18,285	4,900,467	15,100	3,080,400
Miscellaneous [c]......	....	156,820	....	188,984
Total value, eliminating duplications....	....	37,123,501	....	43,312,947

[a] Value not included in total value for State.

[b] Value included under "Miscellaneous."

[c] 1916: Gypsum, manganese and manganiferous ores, salt, and sand and gravel; 1917: Gems and precious stones, gypsum, manganiferous ore, zinc and lead pigments, salt, sand and gravel, and tungsten ore.

Mineral production of New York in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Aluminum....pounds..	(a b)	(a b)	(a b)	(a b)
Cement....barrels..	5,707,892	$5,804,444	5,466,355	$7,092,051
Clay products....	....	11,755,012	....	11,428,399
Clay, raw....short tons..	11,158	b 36,413	11,894	b 51,505
Coke....do....	775,014	b 3,033,276	993,184	b 6,889,424
Diatomaceous earth....	....	(a)	....	(a)
Emery....short tons..	15,282	123,901	15,941	170,223
Feldspar....do....	17,426	82,461	13,462	62,003
Ferroalloys....long tons..	(a b)	(a b)	12,677	b 3,289,472
Garnet, abrasive....short tons..	5,840	198,200	4,786	193,440
Gems and precious stones....	....	(a)	....	....
Graphite:				
Artificial....pounds..	8,397,281	(a b)	10,474,649	(c)
Crystalline....do....	(a)	(a)	2,941,040	261,548
Gypsum....short tons..	579,827	1,459,587	606,268	2,293,418
Iron ore:				
Sold to furnaces....long tons..	1,464,917	5,571,429	1,356,011	7,381,333
Sold for paint....do....	13,011	34,296	11,212	(a)
Iron, pig....do....	2,289,608	b 40,537,240	2,276,367	b 52,318,661
Lime....short tons..	117,490	636,668	108,788	892,855
Magnesium....pounds..	39,163	b 187,443	83,000	b 168,000
Marl, calcareous....short tons..	(a)	(a)	(a)	(a)
Mica....	....	(a)	....	....
Millstones....	....	10,287	....	22,103
Mineral waters....gallons sold..	7,746,490	697,650	7,819,314	562,874
Natural gas....	....	2,355,320	....	2,499,303
Natural-gas gasoline....gallons..	213,055	34,883	154,882	28,377
Peat....short tons..	(a)	(a)	2,619	6,027
Petroleum....barrels..	874,087	2,190,195	879,685	2,850,378
Potash (K_2O)....short tons..	(a)	(a)	5	2,086
Pyrite....long tons..	(a)	(a)	(a)	(a)
Salt....short tons..	1,972,285	3,698,798	2,164,069	5,371,713
Sand and gravel....do....	8,098,097	2,644,829	7,119,013	3,046,447
Sand-lime brick....	....	d 109,037	....	130,626
Silica (quartz)....short tons..	(a)	(a)	(a)	(a)
Slate....	....	21,345	....	55,207
Stone....	....	5,342,954	....	5,399,403
Talc, fibrous....short tons..	93,236	961,510	74,671	881,462
Zinc....do....	4,507	1,207,973	5,192	1,059,186
Miscellaneous [e]....	....	28,406,455	....	33,468,130
Total value, eliminating duplications....	....	45,619,119	....	52,123,552

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] Data not available.

[d] Exclusive of fancy brick, value for which is included under "Miscellaneous."

[e] 1916: Aluminum, diatomaceous earth, ferroalloys, gems and precious stones, artificial graphite, crystalline graphite, calcareous marl, mica, peat, potash, pyrite, fancy brick (sand-lime), and silica (quartz): 1917: Aluminum, diatomaceous earth, iron ore sold for paint, calcareous marl, pyrite, and silica (quartz).

Mineral production of North Carolina in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Aluminum.....pounds..	(a b)	(a b)	(a b)	(a b)
Barytes.....short tons..	878	$3,246	1,019	$5,080
Chromic iron ore.....long tons..			(a)	(a)
Clay products.....		1,551,436		1,662,307
Clay, raw.....short tons..	17,562	[b] 151,823	17,426	[b] 182,176
Copper.....pounds..	9,800	2,411	124,991	34,123
Corundum.....short tons..			820	67,461
Feldspar.....do....	34,670	77,446	47,559	131,442
Garnet, abrasive.....do....	(a)	(a)	(a)	(a)
Gems and precious stones.....		343		(a)
Gold.....fine ounces (troy)..	1,269	26,237	590	12,187
Graphite, amorphous.....short tons..	(a)	(a)		
Iron ore.....long tons..	64,306	(a)	90,957	445,898
Lead.....short tons..			1	222
Lime.....do....	(a)	(a)	(a)	(a)
Manganese ore.....long tons..			102	(a)
Marl (calcareous).....short tons..	7,500	12,000	11,728	29,261
Mica.....		422,580		577,341
Millstones.....		(a)		(a)
Mineral waters.....gallons sold..	137,817	19,010	103,659	15,664
Monazite sand.....pounds..	(a)	(a)	(a)	(a)
Sand and gravel.....short tons..	554,381	150,209	543,364	231,813
Silica (quartz).....do....	(a)	(a)	(a)	(a)
Silver.....fine ounces (troy)..	663	436	1,110	915
Stone.....		1,975,876		1,896,554
Talc.....short tons..	1,787	41,824	2,175	41,766
Tin (metallic equivalent).....do....	(a)	(a)		
Miscellaneous [c].....		854,897		4,223,737
Total value, eliminating duplications.....		4,595,551		5,246,391

---

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Aluminum, abrasive garnet, amorphous graphite, iron ore, lime, millstones, monazite sand, silica (quartz), and tin; 1917: Aluminum, chromic iron ore, abrasive garnet, gems and precious stones, lime, manganese ore, millstones, monazite sand, and silica (quartz).

Mineral production of North Dakota in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Briquets, fuel.....short tons..			(a b)	(a b)
Clay products.....		$264,457		$294,016
Clay, raw.....short tons..	(a b)	(a b)	(a b)	(a b)
Coal.....do....	634,912	946,082	790,548	1,425,750
Mineral waters.....gallons sold..	766,000	14,500	556,000	12,837
Natural gas.....		(a)		(a)
Sand and gravel.....short tons..	(a)	(a)	5,750	4,425
Sand-lime brick.....		(a)		(a)
Miscellaneous [c].....		59,283		22,527
Total value, eliminating duplications.....		1,283,809		1,749,549

---

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Raw clay, natural gas, sand and gravel, and sand-lime brick; 1917: Fuel briquets, raw clay, natural gas, and sand-lime brick.

Mineral production of Ohio in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Bromine....pounds..	78,773	$87,361	(a)	(a)
Calcium chloride....short tons..	(a)	(a)	(a)	(a)
Cement....barrels..	[b] 2,142,931	[b] 2,517,949	1,565,394	$2,328,432
Clay products....	....	44,947,877	....	52,466,716
Clay, raw....short tons..	324,722	[c] 309,369	396,796	[c] 568,687
Coal....do....	34,728,219	46,150,907	40,748,734	100,897,148
Coke....do....	1,803,268	[c] 6,894,619	3,694,302	[c] 23,473,764
Ferroalloys....long tons..	91,032	[c] 2,179,338	79,951	[c] 3,754,745
Grindstones and pulpstones....	....	637,919	....	894,380
Gypsum....short tons..	286,678	927,859	270,538	1,304,497
Iron ore....long tons..	1,800	(a)	....	....
Iron, pig....do....	8,689,030	[c] 136,855,228	8,469,052	[c] 231,165,093
Lime....short tons..	570,972	2,702,953	479,856	2,975,466
Mineral waters....gallons sold..	4,102,922	161,160	3,113,093	136,710
Natural gas....	....	15,601,144	....	18,434,814
Natural-gas gasoline....gallons..	2,638,571	470,804	5,439,560	1,051,376
Oilstones and scythestones....	....	(a)	....	(a).
Petroleum....barrels..	7,744,511	16,154,940	7,750,540	21,104,483
Potash (K_2O)....short tons..	(a)	(a)	25	14,077
Pyrite....long tons..	13,551	36,114	13,218	29,557
Salt....short tons..	938,867	2,038,749	1,026,803	2,839,575
Sand and gravel....do....	8,359,250	3,559,952	6,192,602	4,375,549
Sand and sandstone (finely ground)....do....	(a)	(a)	(a)	(a)
Sand-lime brick....	....	(a)	....	(a)
Stone....	....	6,611,266	....	6,486,605
Sulphuric acid [d]....short tons..	(a)	(a)	196,079	2,501,029
Miscellaneous [e]....	....	2,481,531	....	341,005
Total value, eliminating duplications....	....	145,088,485	....	218,181,419

[a] Value included under "Miscellaneous."

[b] Exclusive of natural cement, value for which is included under "Miscellaneous."

[c] Value not included in total value for State.

[d] From zinc smelting.

[e] 1916: Calcium chloride, natural cement, iron ore, oilstones and scythestones, potash, sand and sandstone (finely ground), sand-lime brick, and sulphuric acid from zinc smelting; 1917: Bromine, calcium chloride, oilstones and scythestones, sand and sandstone (finely ground), and sand-lime brick.

Mineral production of Oklahoma in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asphalt:				
Natural.........short tons..	15,431	$112,555	5,793	$34,344
Oil.........do....	(a)	(a)	(a)	(a)
Cement.........barrels..	1,712,116	2,188,325	1,736,761	2,633,479
Clay products.........		1,410,657		1,857,546
Coal.........short tons..	3,608,011	7,525,427	4,386,844	12,335,413
Gems and precious stones.........		(a)		
Gypsum.........short tons..	161,661	429,350	158,017	562,767
Lead.........do....	12,115	1,671,870	26,358	4,533,576
Lime.........do....	(a)	(a)	(a)	(a)
Mineral paints (zinc and lead pigments)..do...	(a b)	(a b)	(a b)	(a b)
Mineral waters.........gallons sold..	1,353,513	40,189	852,381	26,997
Natural gas.........		12,014,706		13,984,656
Natural-gas gasoline.........gallons..	48,359,602	5,865,145	115,123,424	21,541,905
Petroleum.........barrels..	107,071,715	128,463,805	107,507,471	181,646,981
Salt.........short tons..	(a)	(a)	(a)	(a)
Sand and gravel.........do....	574,844	196,206	463,233	244,432
Silver.........fine ounces (troy)..	606	399		
Stone.........		621,056		625,048
Tripoli.........		(c)		(c)
Zinc.........short tons..	28,754	7,706,272	85,835	17,510,340
Miscellaneous [d].........		1,380,722		1,721,278
Total value, eliminating duplications....		169,556,331		259,134,377

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.
[c] Included in Missouri figures. Not separable.
[d] 1916: Oil asphalt, gems and precious stones, lime, zinc and lead pigments, and salt; 1917: Oil asphalt, lime, zinc and lead pigments, and salt.

Mineral production of Oregon in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore.........short tons..	344	$2,772		
Briquets, fuel.........do....	(a b)	(a b)	(a b)	(a b)
Cement.........barrels..	(a)	(a)	(a)	(a)
Chromic iron ore.........long tons..	3,099	37,806	6,701	$164,032
Clay products.........		[c]299,993		[c]331,546
Clay, raw.........short tons..	(a b)	(a b)	(a b)	(a b)
Coal.........do....	42,592	113,976	28,327	95,663
Copper.........pounds..	3,581,886	881,144	2,474,487	675,535
Gems and precious stones.........		4,492		3,355
Gold.........fine ounces (troy)..	92,018	1,902,179	72,166	1,491,798
Gypsum.........short tons..	(a)	(a)	(a)	(a)
Lead.........do....	14	1,932		
Lime.........do....	4,225	35,289	4,498	40,065
Mineral waters.........gallons sold..	30,920	7,961	13,741	2,842
Platinum and allied metals..fine ounces (troy)..	20	1,780	89	9,208
Quicksilver.........flasks..	303	38,145	388	40,864
Sand and gravel.........short tons..	904,078	283,493	698,351	242,529
Silver.........fine ounces (troy)..	231,342	152,223	125,656	103,541
Stone.........		443,524		413,867
Tungsten ore (60% concentrates)...short tons..				71
Miscellaneous [d].........		377,399		533,862
Total value, eliminating duplications....		4,498,632		4,074,247

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.
[c] Exclusive of pottery, value for which is included under "Miscellaneous."
[d] 1916 and 1917: Fuel briquets, cement, pottery, raw clay, and gypsum.

Mineral production of Pennsylvania in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Briquets, fuel........short tons..	19,038	[a] $73,000	84,394	[a] $265,979
Bromine........pounds..	....	....	(b)	(b)
Calcium chloride........short tons..	....	....	(b)	(b)
Cement........barrels..	[c] 28,748,546	[c] 27,915,298	[c] 27,709,442	[c] 34,512,388
Clay products........	....	32,110,690	....	49,162,650
Clay, raw........short tons..	577,147	[a] 1,098,129	511,405	[a] 1,365,870
Coal:				
Anthracite........do....	87,578,493	202,009,561	99,611,811	283,650,723
Bituminous........do....	170,295,424	221,685,175	172,448,142	421,268,808
Coke........do....	31,279,695	[a] 84,710,305	27,912,025	[a] 135,698,040
Copper........pounds..	625,000	153,750	459,200	125,362
Feldspar........short tons..	7,342	56,323	10,013	91,208
Ferroalloys........long tons..	346,370	[a] 34,494,480	356,462	[a] 53,980,132
Gems and precious stones........	....	165	....	(b)
Graphite, crystalline........pounds..	1,095,716	103,377	804,945	77,475
Iron ore:				
Sold to furnaces........long tons..	558,556	702,633	548,674	873,320
Sold for paint........do....	....	....	(b)	(b)
Iron, pig........do....	16,351,131	[a] 293,437,782	15,423,262	[a] 460,677,474
Lime........short tons..	972,343	3,857,553	936,209	5,900,056
Magnesium........pounds..	(a b)	(a b)	....	....
Manganiferous ore........long tons..	451	(b)	....	....
Marl, calcareous........short tons..	(b)	(b)	(b)	(b)
Mica........	....	(b)	....	....
Millstones........	....	(b)	....	(b)
Mineral paints (zinc and lead pigments), ...short tons..	(a b)	(a b)	(a b)	(a b)
Mineral waters........gallons sold..	1,671,637	145,133	1,603,090	147,021
Natural gas........	....	24,513,119	....	28,716,492
Natural-gas gasoline........gallons..	9,714,926	1,726,173	13,826,250	2,778,098
Oilstones........	....	(b)	....	....
Peat........short tons..	(b)	(b)	(b)	(b)
Petroleum........barrels..	7,592,394	19,149,855	7,733,200	25,154,290
Potash (K_2O)........short tons..	(b)	(b)	280	91,505
Pyrite........long tons..	(b)	(b)	(b)	(b)
Salt........short tons..	....	....	(b)	(b)
Sand and gravel........do....	7,442,452	4,023,692	6,354,635	5,283,000
Sand and sandstone (finely ground).....do....	(b)	(b)	(b)	(b)
Sand-lime brick........	....	94,328	....	83,123
Silica (quartz)........short tons..	(b)	(b)	113,346	80,699
Slate........	....	3,124,743	....	3,306,704
Stone........	....	11,021,655	....	14,048,158
Sulphuric acid [d]........short tons..	(b)	(b)	274,932	4,407,588
Talc........do....	(b)	(b)	(b)	(b)
Tripoli........	....	(b)	....	(b)
Miscellaneous [e]........	....	21,852,877	....	22,856,328
Total value, eliminating duplications.....	....	554,501,375	....	880,220,510

---

[a] Value not included in total value for State.

[b] Value included under "Miscellaneous."

[c] Exclusive of natural cement, value for which is included under "Miscellaneous."

[d] From zinc smelting.

[e] 1916: Natural cement, magnesium, manganiferous ore, calcareous marl, mica, millstones, zinc and lead pigments, oilstones, peat, potash, pyrite, sand and sandstone (finely ground), silica (quartz), sulphuric acid from zinc smelting, talc, and tripoli; 1917: Bromine, calcium chloride, natural cement, gems and precious stones, iron ore sold for paint, calcareous marl, millstones, zinc and lead pigments, peat, pyrite, salt, sand and sandstone (finely ground), talc, and tripoli.

Mineral production of Rhode Island in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products		(a)		(a)
Graphite, amorphous ... short tons	(a)	(a)	(a)	(a)
Lime ... do	(a)	(a)	(a)	(a)
Mineral waters ... gallons sold	449,453	$33,050	368,976	$24,975
Sand and gravel ... short tons	(a)	(a)	(a)	(a)
Soapstone ... do	(a)	(a)		
Stone		632,452		518,785
Miscellaneous [b]		123,706		173,363
Total value, eliminating duplications		789,208		717,123

[a] Value included under "Miscellaneous."
[b] 1916: Clay products, amorphous graphite, lime, sand and gravel, and soapstone; 1917: Clay products, amorphous graphite, lime, and sand and gravel.

Mineral production of South Carolina in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Barytes ... short tons	(a)	(a)	(a)	(a)
Clay products		$607,151		$662,801
Clay, raw ... short tons	32,881	[b] 170,070	40,448	[b] 173,706
Gems and precious stones				(a)
Gold ... fine ounces (troy)	15	320	52	1,083
Manganese ore ... long tons			405	(a)
Manganiferous ore ... do			650	(a)
Marl, calcareous ... short tons	(a)	(a)	(a)	(a)
Mica		(a)		
Mineral waters ... gallons sold	427,905	63,818	289,094	45,729
Phosphate rock ... long tons	53,047	211,125	33,485	188,482
Pyrite ... do	(a)	(a)		
Sand and gravel ... short tons	54,018	21,211	98,068	42,162
Silver ... fine ounces (troy)	28	18	3	2
Stone		447,940		427,531
Miscellaneous [c]		40,490		75,507
Total value, eliminating duplications		1,392,073		1,393,297

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.
[c] 1916: Barytes, calcareous marl, mica, and pyrite; 1917: Barytes, gems and precious stones, manganese and manganiferous ores, and calcareous marl.

Mineral production of South Dakota in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products		$115,474		$47,213
Clay, raw ... short tons			(a b)	(a b)
Coal ... do	8,886	18,021	8,042	23,346
Copper ... pounds			10,707	2,923
Gold ... fine ounces (troy)	360,909	7,460,644	356,245	7,364,233
Gypsum ... short tons	(a)	(a)	(a)	(a)
Lead ... do	18	2,443	34	5,855
Lime ... do	5,772	44,033	4,463	37,589
Lithium minerals ... do	548	10,970	(a)	(a)
Mica		59,770		11,008
Mineral waters ... gallons sold	470,725	20,512	443,167	13,545
Natural gas		(a)		(a)
Pyrite ... long tons	145	966	(a)	(a)
Sand and gravel ... short tons	1,095,594	133,755	194,520	49,654
Sand-lime brick		32,139		(a)
Silver ... fine ounces (troy)	215,205	141,605	186,765	153,894
Stone		205,497		182,907
Tin ... short tons			10	12,300
Tungsten ore (60 per cent concentrates) ... do	239	404,775	270	299,644
Miscellaneous[c]		46,076		147,062
Total value, eliminating duplications		8,696,680		8,348,684

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Gypsum and natural gas; 1917: Raw clay, gypsum, lithium minerals, natural gas, pyrite, and sand-lime brick.

Mineral production of Tennessee in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Aluminum ... pounds	(a b)	(a b)	(a b)	(a b)
Barytes ... short tons	82,416	$123,986	16,972	$79,058
Bauxite ... long tons	(a)	(a)	(a)	(a)
Cement ... barrels	(a)	(a)	(a)	(a)
Clay products		1,983,957		1,969,226
Clay, raw ... short tons	101,617	[b] 209,951	106,535	[b] 280,136
Coal ... do	6,137,449	7,522,445	6,194,221	13,592,998
Coke ... do	382,175	[b] 1,062,065	411,326	[b] 2,031,272
Copper ... pounds	14,679,794	3,611,229	16,033,749	4,377,213
Ferroalloys ... long tons	12,966	(a b)	30,987	[b] 1,445,132
Flint lining for tube mills ... short tons			(a)	(a)
Gold ... fine ounces (troy)	278	5,739	258	5,326
Iron ore ... long tons	467,741	736,397	520,460	1,235,718
Iron, pig ... do	329,342	[b] 4,981,538	346,638	[b] 9,102,441
Lead ... short tons	16	2,274	2,531	435,326
Lime ... do	109,533	378,017	101,836	504,599
Manganese ore ... long tons	429	8,380	1,996	75,066
Manganiferous ore ... do			83	(a)
Mineral waters ... gallons sold	799,346	48,416	758,193	47,362
Natural gas		1,150		2,450
Petroleum ... barrels	677	1,317	12,196	28,448
Phosphate rock ... long tons	409,803	1,500,418	506,679	2,101,040
Potash (K_2O) ... short tons			6	5,000
Pyrite ... long tons	(a)	(a)	(a)	(a)
Sand and gravel ... short tons	1,092,270	414,225	885,957	489,577
Sand and sandstone (finely ground) ... do			(a)	(a)
Silica (quartz) ... do	(a)	(a)		
Silver ... fine ounces (troy)	94,701	62,313	99,063	81,619
Slate				(a)
Stone		1,753,180		1,635,573
Sulphuric acid (60° Baumé)[c] ... short tons	(a)	(a)	(a)	(a)
Zinc ... do	26,428	7,082,634	28,498	5,813,501
Miscellaneous[d]		9,898,286		13,148,928
Total value, eliminating duplications		28,277,365		36,910,448

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] From copper smelting.

[d] 1916: Aluminum, bauxite, cement, ferroalloys, pyrite, silica (quartz), and sulphuric acid from copper smelting; 1917: Aluminum, bauxite, cement, flint lining for tube mills, manganiferous ore, pyrite, sand and sandstone (finely ground), slate, and sulphuric acid from copper smelting.

Mineral production of Texas in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asphalt:				
Natural........short tons..	(a)	(a)	(a)	(a)
Oil........do....	127,259	$1,631,920	160,739	$2,292,036
Cement........barrels..	2,327,659	3,177,104	2,358,944	3,661,328
Clay products........	....	2,837,960	....	3,451,806
Clay, raw........short tons..	2,936	[b] 10,531	4,446	[b] 22,477
Coal........do....	1,987,503	3,092,663	2,355,815	4,177,608
Copper........pounds..	99,569	24,494	23,132	6,315
Fuller's earth........short tons..	(a)	(a)	(a)	(a)
Gems and precious stones........	....	908	....	(a)
Gold........fine ounces (troy)..	20	414	1	22
Graphite, crystalline........pounds..	(a)	(a)	(a)	(a)
Gypsum........short tons..	197,785	653,288	257,328	996,262
Lead........do....	25	3,445	1	214
Lime........do....	54,049	307,759	52,742	361,808
Manganese ore........long tons..	(a)	(a)	25	(a)
Manganiferous ore........do....	....	....	135	(a)
Mineral waters........gallons sold..	703,002	97,513	541,178	72,175
Natural gas........	....	3,143,871	....	3,192,625
Natural-gas gasoline........gallons..	1,292,811	201,023	6,920,405	1,149,441
Petroleum........barrels..	27,644,605	25,760,335	32,413,287	42,891,555
Quicksilver........flasks..	6,306	793,862	10,791	1,136,508
Salt........short tons..	75,762	427,119	85,181	564,029
Sand and gravel........do....	2,617,409	957,794	1,580,939	716,457
Sand-lime brick........	....	45,092	....	65,102
Silver........fine ounces (troy)..	653,455	429,973	595,789	490,930
Stone........	....	698,449	....	697,540
Strontium ore........short tons..	....	....	(a)	(a)
Sulphur........long tons..	(a)	(a)	(a)	(a)
Zinc........short tons..	116	31,140	11	2,313
Miscellaneous [c]........	....	3,395,445	....	11,626,795
Total value, eliminating duplications....	....	47,711,571	....	77,552,369

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Natural asphalt, fuller's earth, crystalline graphite, manganese ore, and sulphur; 1917: Natural asphalt, fuller's earth, gems and precious stones, crystalline graphite, manganese and manganiferous ores, strontium ore, and sulphur.

Mineral production of Utah in 1916 and 1917.

Product.		1916		1917	
		Quantity.	Value.	Quantity.	Value.
Antimony ore	short tons	73	$590	25	$3,325
Asphalt	do	26,874	633,440	35,192	569,325
Cement	barrels	892,596	1,467,564	899,599	1,461,689
Clay products			[a]885,357		952,863
Clay, raw	short tons	(b c)	(b c)	4,079	[c]8,298
Coal	do	3,567,428	5,795,944	4,125,230	8,531,382
Coke	do	(b c)	(b c)	(b c)	(b c)
Copper	pounds	240,275,222	59,107,705	246,674,153	67,342,044
Diatomaceous earth					(b)
Gems and precious stones			8,265		(b)
Gold	fine ounces (troy)	172,938	3,574,947	162,306	3,355,156
Gypsum	short tons	27,727	83,994	(b)	(b)
Iron ore	long tons	45,514	(b)	48,058	(b)
Lead	short tons	100,745	13,902,815	89,261	15,352,888
Lime	do	12,472	77,133	9,130	63,574
Manganese ore	long tons	1,282	22,597	4,195	118,927
Manganiferous ore	do	(b)	(b)	136	(b)
Mineral waters	gallons sold	(b)	(b)		
Molybdenum	pounds	824	800	(b)	(b)
Phosphate rock	long tons	(b)	(b)	(b)	(b)
Potash (K_2O)	short tons	(b)	(b)	3,144	1,234,719
Salt	do	60,653	289,457	79,195	352,145
Sand and gravel	do	185,569	24,048	307,596	82,707
Silver	fine ounces (troy)	13,253,037	8,720,498	13,479,133	11,106,806
Slate			(b)		(b)
Stone			368,705		305,968
Sulphuric acid[d]	short tons			(b)	(b)
Tungsten ore (60% concentrates)	do	20	29,766	33	36,085
Uranium and vanadium ores	do		10,000		29,173
Zinc	do	14,786	3,962,719	10,643	2,171,261
Miscellaneous[e]			2,551,809		2,411,859
Total value, eliminating duplications			99,734,209		113,589,282

[a] Exclusive of pottery, value for which is included under "Miscellaneous."
[b] Value included under "Miscellaneous."
[c] Value not included in total value for State.
[d] From copper smelting.
[e] 1916: Pottery, raw clay, coke, iron ore, manganiferous ore, mineral waters, phosphate rock, potash, and slate; 1917: Coke, diatomaceous earth, gems and precious stones, gypsum, iron ore, manganiferous ore, molybdenum, phosphate rock, slate, and sulphuric acid from copper smelting.

Mineral production of Vermont in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Clay products	....	$94,779	....	$98,344
Clay, raw ... short tons	5,397	[a] 40,684	2,766	[a] 27,082
Copper ... pounds	273,439	67,264	153,900	42,914
Feldspar ... short tons	(b)	(b)	....	....
Gold ... fine ounces (troy)	....	....	3	71
Lime ... short tons	43,365	236,133	46,169	364,071
Mineral waters ... gallons sold	72,590	15,395	94,500	17,705
Sand and gravel ... short tons	68,892	34,481	51,827	40,624
Scythestones	....	(b)	....	(b)
Silver ... fine ounces (troy)	2,501	1,646	487	410
Slate	....	1,607,901	....	1,858,397
Stone	....	5,729,676	....	5,920,799
Talc and soapstone ... short tons	73,215	591,175	93,960	625,150
Miscellaneous	....	8,654	....	18,078
Total value, eliminating duplications	....	8,297,104	....	8,980,573

[a] Value not included in total value for State. [b] Value included under "Miscellaneous."

Mineral production of Virginia in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asbestos ... short tons	(a)	(a)	(a)	(a)
Barytes ... do	(a)	(a)	(a)	(a)
Briquets, fuel ... do	(a b)	(a b)	(a b)	(a b)
Cement ... barrels	(a)	(a)	(a)	(a)
Clay products	....	c $1,676,723	....	$1,658,042
Clay, raw ... short tons	(a b)	(a b)	3,724	[b] 6,263
Coal ... do	9,707,474	10,261,424	10,087,091	20,126,713
Coke ... do	1,242,332	[b] 3,924,918	1,304,280	[b] 5,785,934
Copper ... pounds	553,800	136,235	36,630	10,000
Emery ... short tons	....	....	(a)	(a)
Feldspar ... do	(a)	(a)	....	....
Ferroalloys ... long tons	....	....	7,217	[b] 1,759,170
Gems and precious stones	....	565	....	2,677
Gold ... fine ounces (troy)	43	885	65	1,343
Gypsum ... short tons	(a)	(a)	(a)	(a)
Iron ore ... long tons	486,798	1,000,118	472,337	1,182,449
Iron, pig ... do	444,491	[b] 7,140,002	562,299	[b] 15,708,295
Lead ... short tons	728	100,453	859	147,794
Lime ... do	326,812	1,279,658	307,195	1,820,446
Manganese ore ... long tons	4,417	118,342	12,360	588,806
Manganiferous ore ... do	37,700	104,794	84,396	185,968
Marl, calcareous ... short tons	30,243	51,675	27,300	52,850
Mica	....	20,954	....	25,540
Millstones	....	25,752	....	18,980
Mineral waters ... gallons sold	2,313,616	248,906	2,518,050	237,788
Peat ... short tons	....	....	(a)	(a)
Pyrite ... long tons	148,502	925,243	170,382	1,378,043
Salt ... short tons	(a)	(a)	(a)	(a)
Sand and gravel ... do	641,595	226,373	1,126,527	532,310
Sand and sandstone (finely ground) ... do	....	....	(a)	(a)
Silica (quartz) ... do	(a)	(a)	....	....
Silver ... fine ounces (troy)	783	515	4,518	3,723
Slate	....	165,483	....	135,380
Stone	....	1,580,161	....	1,612,118
Talc and soapstone ... short tons	28,355	564,228	26,667	489,062
Titanium minerals:				
Ilmenite ... do	95	1,900	259	6,576
Rutile ... do	110	16,500	206	32,960
Zinc ... do	2,276	609,866	1,703	347,352
Miscellaneous[d]	....	1,474,780	....	1,725,817
Total value, eliminating duplications	....	20,560,956	....	32,243,648

[a] Value included under "Miscellaneous."
[b] Value not included in total value for State.
[c] Exclusive of pottery, value for which is included under "Miscellaneous."
[d] 1916: Asbestos, barytes, fuel briquets, cement, pottery, raw clay, feldspar, gypsum, salt, and silica (quartz); 1917: Asbestos, barytes, fuel briquets, cement, emery, gypsum, peat, salt, and sand and sandstone (finely ground).

Mineral production of Washington in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Antimony ore......short tons..	400	$3,355		
Briquets, fuel......do....	(a b)	(a b)	(a b)	(a b)
Cement......barrels..	1,575,919	2,447,779	1,403,191	$2,367,045
Chromic iron ore......long tons..			(a)	(a)
Clay products......		[c] 1,589,574		1,533,039
Clay, raw......short tons..	1,840	[b] 6,251	1,613	[b] 9,248
Coal......do....	3,038,588	6,907,428	4,009,902	10,727,362
Coke......do....	(a b)	(a b)	(a b)	(a b)
Copper......pounds..	2,645,022	650,675	2,199,518	600,468
Diatomaceous earth......		10,700		18,910
Ferroalloys......long tons..			(a b)	(a b)
Gems and precious stones......		850		(a)
Gold......fine ounces (troy)..	27,944	577,655	23,816	492,324
Iron, pig......long tons..			2,361	(a b)
Lead......short tons..	2,700	372,550	4,895	841,913
Lime......do....	26,895	166,653	23,328	156,553
Magnesite......do....	715	5,362	105,175	783,188
Manganese ore......long tons..	(a)	(a)		
Manganiferous ore......do....	(a)	(a)		
Mineral waters......gallons sold..	151,528	9,476	155,265	7,265
Molybdenum......pounds..			(a)	(a)
Platinum and allied metals.fine ounces (troy)..			(a)	(a)
Potash (K_2O)......short tons..	(a)	(a)		
Quicksilver......flasks..	75	9,442		
Sand and gravel......short tons..	1,401,237	387,337	895,120	199,565
Sand-lime brick......		(a)		(a)
Silica (quartz)......short tons..	(a)	(a)		
Silver......fine ounces (troy)..	335,121	220,510	282,320	232,632
Stone......		903,635		454,594
Strontium ore......short tons..	(a)	(a)	(a)	(a)
Tungsten ore (60 per cent concentrates)..do....	11	15,230	10	13,500
Zinc......do....	847	226,960	598	121,948
Miscellaneous [d]......		1,037,350		1,809,700
Total value, eliminating duplications.....		14,521,014		18,576,052

---

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] Exclusive of pottery, value for which is included under "Miscellaneous."

[d] 1916: Fuel briquets, pottery, coke, manganese and manganiferous ores, potash, sand-lime brick, silica (quartz), and strontium ore; 1917: Fuel briquets, chromic iron ore, coke, ferroalloys, gems and precious stones, pig iron, molybdenum, platinum and allied metals, sand-lime brick, and strontium ore.

Mineral production of West Virginia in 1916 and 1917.

Product.		1916		1917	
		Quantity.	Value.	Quantity.	Value.
Bromine	pounds	136,544	$179,126	74,947	$42,431
Calcium chloride	short tons	5,924	42,263	3,691	63,644
Cement	barrels	(a)	(a)	(a)	(a)
Clay products			7,634,321		9,608,065
Clay, raw	short tons	122,944	[b] 126,283	127,024	[b] 189,672
Coal	do	86,460,127	102,366,092	86,441,667	200,659,368
Coke	do	2,521,309	[b] 6,567,505	3,349,761	[b] 16,715,083
Grindstones and pulpstones			(a)		162,310
Iron ore	long tons	8,605	(a)	4,632	(a)
Iron, pig	do	348,743	(a b)	355,956	(a b)
Lime	short tons	277,721	1,008,021	245,569	1,268,343
Marl, calcareous	do			(a)	(a)
Mineral waters	gallons sold	287,466	46,686	156,267	37,529
Natural gas			47,603,396		57,389,161
Natural-gas gasoline	gallons	18,765,056	3,025,293	32,668,647	6,511,813
Petroleum	barrels	8,731,184	21,914,080	8,379,285	27,246,960
Salt	short tons	33,389	122,669	24,844	191,044
Sand and gravel	do	1,054,878	777,952	877,679	966,763
Sand and sandstone (finely ground)	do	(a)	(a)	(a)	(a)
Stone			1,500,809		1,841,071
Sulphuric acid [c]	short tons			(a)	(a)
Miscellaneous [d]			6,470,753		10,141,380
Total value, eliminating duplications			187,043,011		306,916,191

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] From zinc smelting.

[d] 1916: Cement, grindstones and pulpstones, iron ore, pig iron, and sand and sandstone (finely ground); 1917: Cement, iron ore, pig iron, calcareous marl, sand and sandstone (finely ground), and sulphuric acid from zinc smelting.

Mineral production of Wisconsin in 1916 and 1917.

Product.		1916		1917	
		Quantity.	Value.	Quantity.	Value.
Briquets, fuel	short tons	(a b)	(a b)	(a b)	(a b)
Clay products			[c] $905,910		$1,122,121
Clay, raw	short tons	(a b)	(a b)	(a b)	(a b)
Coke	do	(a b)	(a b)	(a b)	(a b)
Iron ore:					
Sold to furnaces	long tons	1,529,459	3,644,542	1,179,709	3,913,437
Sold for paint	do	1,599	(a)	982	(a)
Iron, pig	do	423,973	[b] 7,534,327	402,732	[b] 11,082,274
Lead	short tons	3,043	419,934	4,139	711,908
Lime	do	266,805	1,207,059	169,650	1,087,578
Manganiferous ore	long tons	3,982	6,570		
Mineral paints (zinc and lead pigments),	short tons	(a b)	(a b)	(a b)	(a b)
Mineral waters	gallons sold	7,696,813	1,507,679	6,296,634	1,362,498
Potash (K_2O)	short tons	125	67,625	277	259,928
Pyrite	long tons	(a)	(a)	(a)	(a)
Sand and gravel	short tons	3,544,766	894,202	3,609,869	1,089,860
Sand-lime brick			(a)		(a)
Silica (quartz)	short tons	(a)	(a)	(a)	(a)
Stone			2,757,790		2,787,023
Sulphuric acid [d]	short tons	(a)	(a)	(a)	(a)
Zinc	do	56,803	15,223,204	59,742	12,187,368
Miscellaneous [e]			5,251,992		9,017,291
Total value, eliminating duplications			27,082,175		24,976,780

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] Exclusive of pottery, value for which is included under "Miscellaneous."

[d] From zinc smelting.

[e] 1916: Fuel briquets, pottery, raw clay, coke, iron ore sold for paint, manganiferous ore, zinc and lead pigments, pyrite, sand-lime brick, silica (quartz), and sulphuric acid from zinc smelting; 1917: Fuel briquets, raw clay, coke, iron ore sold for paint, zinc and lead pigments, pyrite, sand-lime brick, silica (quartz), and sulphuric acid from zinc smelting.

Mineral production of Wyoming in 1916 and 1917.

Product.	1916		1917	
	Quantity.	Value.	Quantity.	Value.
Asbestos.....short tons..	....	....	(a)	(a)
Chromic iron ore.....long tons..	(a)	(a)	....	....
Clay products..........	....	$90,199	....	$106,896
Clay, raw.....short tons..	(a b)	(a b)	(a b)	(a b)
Coal.....do....	7,910,647	12,239,707	8,575,619	16,593,283
Copper.....pounds..	2,610,622	642,213	2,027,857	553,605
Gems and precious stones..........	....	(a)	....	(a)
Gold.....fine ounces (troy)..	995	20,566	182	3,762
Gypsum.....short tons..	46,964	141,408	55,844	197,867
Iron ore.....long tons..	545,774	(a)	543,846	(a)
Lime.....short tons..	(a)	(a)	(a)	(a)
Manganese ore.....long tons..	....	....	30	(a)
Mineral waters.....gallons sold..	53,891	7,269	53,726	7,899
Natural gas..........	....	(a)	....	(a)
Petroleum.....barrels..	6,234,137	5,644,080	8,978,680	11,047,876
Phosphate rock.....long tons..	(a)	(a)	(a)	(a)
Platinum and allied metals..fine ounces (troy)..	(a)	(a)	(a)	(a)
Sand and gravel.....short tons..	769,739	88,972	(a)	(a)
Silver.....fine ounces (troy)..	5,524	3,635	3,415	2,814
Sodium salts from natural sources..short tons..	(a)	(a)	(a)	(a)
Stone..........	....	64,509	....	158,180
Sulphur.....long tons..	(a)	(a)	(a)	(a)
Miscellaneous [c]..........	....	744,694	....	899,105
Total value, eliminating duplications.....	....	19,683,292	....	29,567,250

[a] Value included under "Miscellaneous."

[b] Value not included in total value for State.

[c] 1916: Chromic iron ore, raw clay, gems and precious stones, iron ore, lime, natural gas, phosphate rock, platinum and allied metals, sodium salts from natural sources, and sulphur; 1917: Asbestos, raw clay, gems and precious stones, iron ore, lime, manganese ore, natural gas, phosphate rock, platinum and allied metals, sand and gravel, sodium salts from natural sources, and sulphur.

PREFATORY NOTE TO THE REPORTS ON GOLD, SILVER, COPPER, LEAD, AND ZINC.

By H. D. McCaskey.

In the mining industry five metals are closely related in both the genesis and the geologic occurrence of their ores. They also hold together in mining and in metallurgical treatment. They are gold, silver, copper, lead, and zinc. Of their ores some contain all five metals, many contain three or four, and few contain only one. Gold and silver, for instance, on the one hand, and lead and zinc, on the other, almost always stand in close genetic relations, and the ores of each two are usually mined together. Copper ores almost invariably produce some silver and gold as well as copper, and lead ores, with certain exceptions, produce notable supplies of silver. Zinc ores in the Western States contribute also to the production of silver. In the same mine sometimes, and in the same mining district frequently, all five metals occur in commercial quantity.

This situation is recognized by the United States Geological Survey in its publication of the annual reports on the mineral resources of the country. Hence the general treatment of each of the five metals in the general reports and the grouping together of the related metals in the various mines reports descriptive of individual or geographically grouped States.

To facilitate advance publication, the complete report upon these five metals is therefore divided into 16 sections, each of which is published separately. The first four sections give figures of output for the calendar year in marketable form for the metals named as obtained from the smelters, refineries, and mints, and general reviews of the respective industries for the entire country. The last 12 sections give the production (called "mine production") as obtained from the mines so far as possible in terms of recoverable metal in ores and other material sold or treated during the calendar year and supply information in detail relative to the mining industry in the respective States, counties, and mining districts. The figures given in the general reports are the final official statistics of production for the country and of the States. The general report on gold and silver includes the statistics of recovered precious metals as determined jointly by the Bureau of the Mint and the United States Geological Survey.

The 16 sections, which appear as separate chapters in this volume, are as follows:

Gold and silver (general report).
Copper (general report).
Lead (general report).
Zinc (general report).
Gold, silver, copper, lead, and zinc in the Eastern States (mines report).
Silver, copper, lead, and zinc in the Central States (mines report).
Gold, silver, copper, and lead in Alaska (mines report).
Gold, silver, copper, lead, and zinc in Arizona (mines report).
Gold, silver, copper, lead, and zinc in California and Oregon (mines report).
Gold, silver, copper, lead, and zinc in Colorado (mines report).
Gold, silver, copper, lead, and zinc in Idaho and Washington (mines report).
Gold, silver, copper, lead, and zinc in Montana (mines report).
Gold, silver, copper, lead, and zinc in Nevada (mines report).
Gold, silver, copper, lead, and zinc in New Mexico and Texas (mines report).
Gold, silver, copper, and lead in South Dakota and Wyoming (mines report).
Gold, silver, copper, lead, and zinc in Utah (mines report).

In measurements of ores, concentrates, and similar material the short ton of 2,000 pounds is used throughout. The ore classification is necessarily arbitrary in part. An ore is generally understood to be worked at a profit for one or more metals. The complex nature of western ores especially and the gradations from one well-recognized class to another render essential some fixed measures for the terminology used. The dry or siliceous ores comprise gold and silver ores proper, as well as fluxing ores carrying considerable quantities of iron and manganese oxides and very small quantities of gold and silver, and also precious metal bearing ores carrying copper, lead, or zinc in quantities too low to classify them as copper, lead, zinc, or mixed ores. The copper ores include those carrying more than 2.5 per cent of copper, or even less in the cases of the great disseminated copper deposits of the West and of the copper ores of the Lake Superior region. In general, the lead ores are those containing more than 4.5 per cent of lead and the zinc ores are those containing 25 per cent or more of zinc, both irrespective of their precious-metal content; but some ores of lower grade in lead, and especially in zinc, are treated profitably for these metals, and of course they are then classified as lead or zinc ores, as the case may be. The mixed ores are combinations of the ores enumerated.

The prices used by the United States Geological Survey for calculation of values for the years 1850–1917, inclusive, are as follows:

Prices of silver, copper, lead, and zinc, 1850–1917.

Year.	Silver.[a]	Copper.[b]	Lead.[c]	Zinc.[d]	Year.	Silver.[a]	Copper.[b]	Lead.[c]	Zinc.[d]
	Fine ounce.	*Pound.*	*Pound.*	*Pound.*		*Fine ounce.*	*Pound.*	*Pound.*	*Pound.*
1850	$1.32	$0.22	$0.05	....	1884	$1.11	$0.13	$0.037	$0.044
1851	1.34	.166	.05	....	1885	1.07	.108	.040	.043
1852	1.33	.22	.05	....	1886	.99	.111	.046	.044
1853	1.35	.22	.06	$0.055	1887	.98	.138	.045	.046
1854	1.35	.22	.06	....	1888	.94	.168	.044	.049
1855	1.34	.27	.07	....	1889	.94	.135	.039	.05
1856	1.34	.27	.066	....	1890	1.05	.156	.045	.055
1857	1.35	.25	.06	....	1891	.99	.128	.043	.05
1858	1.34	.23	.06	....	1892	.87	.116	.041	.046
1859	1.36	.22	.055	....	1893	.78	.108	.037	.04
1860	1.35	.23	.056	....	1894	.63	.095	.033	035
1861	1.33	.22	.05	....	1895	.65	.107	.032	.036
1862	1.35	.22	.06	....	1896	.68	.108	.03	.039
1863	1.345	.34	.06	....	1897	.60	.12	.036	.041
1864	1.345	.47	.07	.139	1898	.59	.124	.038	.046
1865	1.337	.392	.066	....	1899	.60	.171	.045	.058
1866	1.339	.342	.07	....	1900	.62	.166	.044	.044
1867	1.33	.254	.065	....	1901	.60	.167	.043	.041
1868	1.326	.23	.065	....	1902	.53	.122	.041	.048
1869	1.325	.242	.06	....	1903	.54	.137	.042	.054
1870	1.328	.212	.06	....	1904	.58	.128	.043	.051
1871	1.325	.241	.06	....	1905	.61	.156	.047	.059
1872	1.322	.356	.064	....	1906	.68	.193	.057	.061
1873	1.297	.280	.06	....	1907	.66	.20	.053	.059
1874	1.278	.220	.06	....	1908	.53	.132	.042	.047
1875	1.24	.227	.058	.07	1909	.52	.13	.043	.054
1876	1.16	.21	.061	.072	1910	.54	.127	.044	.054
1877	1.20	.19	.055	.06	1911	.53	.125	.045	.057
1878	1.15	.166	.036	.049	1912	.615	.165	.045	.069
1879	1.12	.186	.041	.052	1913	.604	.155	.044	.056
1880	1.15	.214	.05	.055	1914	.553	.133	.039	.051
1881	1.13	.182	.048	.052	1915	.507	.175	.047	.124
1882	1.14	.191	.049	.053	1916	.658	.246	.069	.134
1883	1.11	.165	.043	.045	1917	.824	.273	.086	.102

---

[a] Report of Director of the Mint, pp. 212–213, 1914. Equivalent value of fine ounce based on average price and average rate of exchange. For 1916 and 1917 dealers' buying price, New York.

[b] Weed, W. H., Copper handbook, vol. 11, pp. 1339, 1343, for years 1850–1903. By computation from data for years 1850–1860, p. 1339. Survey computations for electrolytic copper since 1904. For 1916 and 1917, average sales price all marketable grades.

[c] New York price, Ingalls, W. R., Lead and zinc in the United States, p. 203, 1908. U. S. Geological Survey since 1904. For 1916, outside spot quotations, New York, for 1917, average sales price.

[d] New York price, 1875–1904, Ingalls, W. R., Lead and zinc in the United States, p. 342, 1908. St. Louis price, U. S. Geological Survey since 1904. The zinc price for 1915, 1916, and 1917, is average sales price for zinc, all grades. Oral communication from C. E. Siebenthal for 1853 and 1864.

It is to be understood, of course, that market values are not received by producers for metals in ore and intermediate products, nor always for metals in marketable form; that payment is made in accordance with contracts for treatment or sale; and that, therefore, average daily quotations do not necessarily agree with average prices received.

Each of the 16 sections mentioned is published in a separate pamphlet for advance distribution, and copies can be obtained, as long as the supply lasts, on request made to the Director, United States Geological Survey, Washington, D. C.

BAUXITE AND ALUMINUM.

By James M. Hill.[1]

BAUXITE.

DOMESTIC PRODUCTION.

The quantity of bauxite marketed in the United States in 1917 was 568,690 long tons, which had a value at the mines of $3,119,058, an increase over the production of 1916 of about 34 per cent in quantity and about 36 per cent in value. The production from the Georgia, Alabama, and Tennessee field in 1917 was 62,134 long tons, an increase of about 26 per cent, and the Arkansas production of 506,556 long tons showed an increase of approximately 35 per cent.

Bauxite produced and consumed in the United States, 1913–1917.

Year.	Domestic production.					
	Georgia, Alabama, and Tennessee.		Arkansas.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1913	40,370	$150,710	169,871	$846,988	210,241	$997,698
1914	24,071	92,508	195,247	976,686	219,318	1,069,194
1915	28,245	144,345	268,796	1,370,489	297,041	1,514,834
1916	49,190	284,810	375,910	2,011,590	425,100	2,296,400
1917	62,134	395,051	506,556	2,724,007	568,690	3,119,058

Year.	Imports.		Exports.[a]		Domestic consumption.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1913	21,456	$85,746	(b)	(b)	231,697	$1,083,444
1914	24,844	96,500	[c] 5,374	$240,084	238,788	925,610
1915	3,420	17,107	16,082	717,186	284,379	814,755
1916	30	87	18,032	987,454	407,098	1,309,033
1917	7,691	28,989	21,791	1,323,926	554,590	1,824,121

---

[1] The statistical data in this report were prepared by Miss H. M. Gaylord, of the United States Geological Survey.

[a] Includes bauxite concentrates.

[b] Included in "All other articles."

[c] From July 1, 1914, includes bauxite concentrates.

Apparently the producers of aluminum consumed about 375,000 tons, the makers of chemicals about 82,000 tons, makers of abrasives about 110,000 tons, and the makers of refractories about 2,400 tons of bauxite in 1917.

As will be seen by the table, though the domestic consumption of bauxite in 1917 also increased 36 per cent over the consumption in 1916, the domestic deposits were able to supply nearly the whole demand. The larger exports were apparently made to Canadian aluminum and abrasive makers.

MARKET AND PRICES.

The market for bauxite in the United States is east of Mississippi River, and the largest consumers are located at or near the cities of East St. Louis and Aurora, Ill.; Detroit, Mich.; Cincinnati, Ohio; Knoxville, Tenn.; Philadelphia and Erie, Pa.; Niagara Falls and New York City, N. Y.; and Boston, Mass. Recently a number of municipal and industrial waterworks have installed small plants for the manufacture of aluminum sulphate for local use in purification of water. A complete list of those known to the United States Geological Survey to be users of bauxite follows:

USERS OF BAUXITE.

Aluminum Co. of America, Pittsburgh, Pa.
Booth Chemical Co., P. O. Box 203, Elizabeth, N. J.
Carborundum Co., Niagara Falls, N. Y.
Charles Lennig & Co. (Inc.), 112 South Front Street, Philadelphia, Pa.
Charles Taylor Sons Co., Cincinnati, Ohio.
Columbus Waterworks, R. D. 5, Columbus, Ohio.
Cumberland Waterworks, R. D. 3, Cumberland, Md.
Detroit Chemical Works, 238 Junction Avenue, Detroit, Mich.
E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Erie Chemical Works, 31 Union Square W., New York, N. Y.
Exolon Co., 156 Sixth Street, Cambridge, Mass.
General Abrasives Co., Niagara Falls, N. Y.
General Refractories Co., Trinity Building, New York, N. Y.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
Jarecki Chemical Co., St. Bernard Station, Cincinnati, Ohio.
Laclede-Christy Clay Products Co., St. Louis, Mo.
Massillon Stone & Fire Brick Co., Massillon, Ohio.
Merrimac Chemical Co., 33 Broad Street, Boston, Mass.
Metropolitan Water District of Omaha, Omaha, Nebr. (R. B. Howell, general manager.)
Montclair Waterworks, Little Falls, N. J.
Norton Co., Worcester, Mass. (also Niagara Falls, N. Y.).
Pennsylvania Salt Manufacturing Co., Widener Building, Philadelphia, Pa.
Springfield Waterworks, Springfield, Mass.
Superior Chemical Co., Joliet, Ill.

Bauxite is graded according to its chemical composition and is sold to the consuming industries on the basis of analysis. Apparently low content of silica and titanium is essential to the aluminum industry, but the content of iron may be fairly high, though bauxites low in iron and titanium are preferred by the makers of alum and aluminum sulphate. Makers of abrasive appear to be able to use bauxites of lower grade and containing larger proportions of silica and iron than are permissible in bauxite for other uses, but most abrasives are made from bauxites low in silica and iron. The bauxite used for refractories must apparently be fairly low in iron.

The prices received for bauxite in 1917, as reported by producers, ranged from $4.75 to $10.50 a long ton; the average price paid for the whole of the domestic bauxite sold in the country was $5.48 a long ton at the shipping point.

WORLD'S PRODUCTION.

Data on the output of the French bauxite mines have been withheld since the beginning of the war.

World's production of bauxite, 1913–1916.

Country.	1913		1914		1915		1916	
	Quantity (longtons).	Value.	Quantity (longtons).	Value.	Quantity (longtons).	Value.	Quantity (longtons).	Value.
United States	210,241	$997,698	219,318	$1,069,194	297,041	$1,514,834	425,100	$2,296,400
France	304,407	(a)	(a)	(a)	(a)	(a)	(a)	(a)
United Kingdom	6,055	7,606	8,286	10,507	11,723	15,393	10,329	(a)
Italy	6,843	16,101	3,844	9,046	6,504	15,942	8,746	(a)
India	1,184	161	514	156	(a)	141	750	2,253

[a] Statistics not available.

From British Guiana it is reported[1] that no further applications for bauxite lands will be granted till after the war. It is also understood that bauxite mined on concessions granted before the ruling was made is under Government control and its exportation may be prohibited at the discretion of the Government. Development[2] on the concessions already granted has been continued, and similar deposits have been found in other parts of the colony.

The Dutch Government has apparently followed the British in stopping the granting of licenses for exploration for bauxite. The Government of The Hague has recently dispatched two engineers to Dutch Guiana to study the bauxite deposits, apparently with the idea of obtaining an adequate knowledge of their potential value before taking further action.

OCCURRENCE AND CHARACTER OF BAUXITE IN THE UNITED STATES.

The known commercial bauxite deposits of the United States are in Calhoun, Cherokee, and Dekalb counties, Ala.; Pulaski and Saline counties, Ark.; Bartow, Floyd, Meriwether, Sumter, and Wilkinson counties, Ga.; and Carter and Hamilton counties, Tenn. A brief description of the geology of the domestic deposits was given in the report for 1916,[3] and detailed descriptions of the deposits in central Georgia have been published by the Georgia Geological Survey.[4]

The bauxite from all localities in the United States, though it may vary in chemical composition, is on the whole similar in general appearance, with the exception of the "granitic bauxite" of the Arkansas field. The greater part of the American bauxite appears to be made up of rounded pebble-like bodies set in a fine-grained matrix, which may also consist of small rounded particles or may be as fine grained as the finest clay. The pebble or pisolite form is so general that it is the conspicuous characteristic of American bauxite.

---

[1] Commerce Repts., No. 300, p. 1139, Dec. 24, 1917.

[2] Supplement to Commerce Repts., Ann. Ser. 44–A, p. 3, Oct. 29, 1917.

[3] Hill, J. M., Bauxite and aluminum in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 161–165, 1917.

[4] Shearer, H. K., A report on the bauxite and fuller's earth of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 31, 1917.

There is only one way to determine the value of bauxite, and that is by chemical analysis, which should show total silica, alumina, titanium oxide, iron oxide, and water. Bauxites of commercial grade should carry at least 52 per cent of alumina.

A few characteristics that indicate in a general way the quality of baxuite may be mentioned, though none of them are to be depended on. In general, bauxite of fair grade will not show the marks of a hammer when it is hit a glancing blow, though some bauxite has been shipped which can be cut with the hammer. Good bauxite that has been dried either in the open or in kilns when thrown on a hard floor has a distinct rattle, which bauxite clay does not have. The pisolites of the lighter-colored bauxites of the central Georgia field have a peculiar brownish-buff color and look something like horn or flint; they ordinarily can not be broken or marked with the finger nail in bauxites of good grade.

Some measure of the relative quality of dried bauxite can be had by grinding a sample in an agate mortar for half a minute. A bauxite of good grade will be found hard to grind and will stick to the mortar with such tenacity that it will have to be scoured out; a poor bauxite or bauxite clay will grind much more easily and will stick very little, if at all; and clay or kaolin grinds with ease and does not stick to the mortar. Similar results are found if the sample is rubbed on glass; the glass will not be scratched by even high-grade bauxite.

NOTES ON THE UNITED STATES BAUXITE MINES.

Alabama.—During 1917 three companies were operating in the Alabama field—the E. I. du Pont de Nemours Co., at the Snider mine, north of Piedmont; the Republic Mining & Manufacturing Co., near Rock Run, Cherokee County; and the Consolidated Mining Co., near Fort Payne, Dekalb County.

The production of bauxite from Alabama in 1917 showed an increase of about 44 per cent over the production in 1916. The output was used for the manufacture of alumina chemicals to the extent of 53 per cent; abrasive, 44 per cent; and refractories, 3 per cent.

Arkansas.—The American Bauxite Co., Globe Bauxite Co., E. I. du Pont de Nemours Co., and Republic Mining & Manufacturing Co. mined bauxite from deposits in Saline and Pulaski counties, Ark. The largest production was made from the deposits near Bauxite, Saline County.

The production from Arkansas in 1917 showed an increase of 35 per cent over the production in 1916, and it is believed that should the demand arise the Arkansas deposits are capable of much greater output and contain considerable reserves. The bauxite mined from the Arkansas deposits is of high grade, as is shown by the fact that more than 71 per cent of the output in 1917 was used for the manufacture of aluminum, nearly 19 per cent from abrasives, 9 per cent for chemicals, and 1 per cent for refractories.

Georgia.—The total production of bauxite from Georgia in 1917 was approximately 52,000 tons, an increase of about 31 per cent over the production in 1916. Wilkinson County produced the largest quantity, Sumter County was second, Floyd County third, Bartow County fourth, and Meriwether County fifth in rank of output.

Georgia bauxite appears to be more suitable for the manufacture of alumina chemicals than for other purposes. The output in 1917 was distributed as follows: 59 per cent for alumina chemicals, 21 per cent for aluminum, and 20 per cent for abrasives.

In Bartow and Floyd counties in 1917 five companies were mining bauxite from deposits near Adairsville, Cave Springs, Hall, Hermitage, Linwood, and Pinson. The total quantity of bauxite shipped from the north Georgia area was approximately 15,000 tons, of which approximately 53 per cent was used for alumina chemicals, 33 per cent for abrasives, and 14 per cent for aluminum.

There was a small production of bauxite from the deposits near Warm Springs, in Meriwether County, which was used for alumina chemicals. It is reported that an eastward extension of these peculiar deposits has been found and will be developed during 1918.

In the central Georgia field three operators reported production of bauxite from deposits in Sumter County and five operators from deposits in Wilkinson County. The production of bauxite from this area was approximately 37,000 long tons, of which 61 per cent was used for alumina chemicals, 23 per cent for aluminum, and 16 per cent for abrasives.

Tennessee.—The bauxite deposits on Missionary Ridge were reported idle during 1917. A small output was made at the mines near Elizabethton, Carter County, but car shortage hampered operations. A new deposit of bauxite has been discovered near Hixon, 15 miles north of Chattanooga.

ALUMINUM.

DOMESTIC PRODUCTION AND CONSUMPTION.

The value of primary aluminum produced in the United States in 1917 was $45,882,000, an increase of 35 per cent over the value of the output in 1916. This increase is due in part to the increased price and in part to the greater output of primary aluminum in 1917. The secondary aluminum recovered during 1917 had a value of $16,711,800, a decrease of about 29 per cent from the value of the output in 1916. Information concerning this phase of the aluminum industry will be found in the chapter of Mineral Resources on secondary metals in 1917, which is now in preparation.

Value of aluminum produced and consumed in the United States, 1913–1917.

Year.	Domestic production.		Imports.[b]	Exports.[c]	Apparent consumption.
	Primary metal.	Secondary metal.[a]			
1913	$9,450,000	$2,199,480	$4,784,302	$966,094	$15,467,688
1914	10,080,000	1,673,140	4,074,583	1,546,510	14,281,213
1915	16,280,000	5,802,100	1,841,779	3,682,117	20,241,762
1916	33,900,000	23,430,200	1,785,870	15,417,134	43,698,936
1917	45,882,000	16,711,800	56,890	14,586,467	48,064,223

[a] Value based on average open market price, as quoted by Eng. and Min. Jour.

[b] Imports for consumption, figures from Department of Commerce reports. Includes aluminum in crude form, leaf, sheets, plates, bars, strips, wire, rods, and all manufactures of; table, kitchen, and hospital ware.

[c] Exports of aluminum and manufactures of; figures from Department of Commerce reports.

MARKET AND PRICES OF ALUMINUM.

In the United States the quoted prices for primary or "virgin" aluminum ranged from 62 cents a pound, in January, to 37 cents a pound, in October, a price which was maintained to the end of the year. The average for the year was 51.59 cents a pound, as compared with 60.71 cents in 1916. These prices are for small lots and immediate delivery, offered in the open market, and do not represent the price received by the single producer of primary aluminum in this country.

Prices of aluminum, 1913–1917, in cents per pound.[a]

Year.	Average open market price, small lots.	Contract price.
1913	23.64	(b)
1914	18.63	(b)
1915	33.98	20–31
1916	60.71	31–37
1917	51.59	31–37

[a] Eng. and Min. Jour. quotations in annual review numbers.

[b] No figures published, but it seems reasonable to believe that contracts were made on approximately the same basis as for 1912.

On March 5, 1918, announcement was made in the papers of Washington, D. C., that the President had fixed the maximum base price of virgin aluminum, 98–99 per cent pure, for lots of 50 tons or over, at 32 cents a pound. This price is subject to revision June 1, 1918.

Secondary aluminum, 98–99 per cent pure, recovered from scrap materials, sold for 56.40 cents a pound at the beginning of 1917. Its price followed the decline of virgin metal to a low of 35 cents a pound in the later part of October, a price which was maintained to the end of 1917.

NOTES ON THE ALUMINUM INDUSTRY.

The Aluminum Co. of America is now operating four electrolytic plants in the United States at which aluminum is made—at Massena and Niagara Falls, N. Y., Maryville, Tenn., and Badin, N. C. The Badin plant made its initial run in 1916, but was not producing much aluminum until August, 1917. Additional power is under development for the Maryville plant, which will further increase the producing capacity of the United States.

The British Aluminum Co. is reported[1] to be enlarging its aluminum works at Kinlochleven, in Scotland. On February 28, 1917,[2] the ministry of munitions took under control the secondary aluminum industry, establishing prices for purchase and resale of various grades of remelted materials containing aluminum and issuing rules for the makers and refiners of such materials, called "aluminum scrap and swaf." It will be recalled that the primary aluminum industry was placed under control December 7, 1915.

USES OF ALUMINUM.

The uses of aluminum have been changed somewhat by war conditions. Pleasure-car automobile makers have restricted the use of metal in bodies and parts of various kinds. Four makers of pleasure cars are making aluminum-alloy engines. Much aluminum is being used for military equipment of all kinds. It is believed that the domestic producers will be able to supply the demand for 1918,[3] but uncertainty as to what the demand will be makes predictions dangerous.

OTHER BAUXITE PRODUCTS.

Nearly 65 per cent of the domestic output of bauxite in 1917 went into aluminum, manufacturers of aluminum salts used nearly 13 per cent, 19 per cent was consumed in the manufacture of bauxite abrasives, and 3 per cent was used by makers of "high-alumina refractories," also called bauxite brick.

Within the last two years many foreign and domestic patents have been issued relating to the use of bauxite in the fixation of nitrogen, the manufacture of aluminum salts, and the fabrication of abrasives and refractories. Copies of these patents may be obtained from the United States Patent Office, Washington, D. C.

ALUMINUM SALTS.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulphate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum, and no figures of domestic production are available for publication.

Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1917 being 19,714 short tons, valued at $1,017,083, a decrease of approximately 28 per cent in quantity and of 14 per cent in value from the production in 1916. The average price reported by makers of alums was $51.60 a short ton. The wholesale market quotations ranged from 4 to 5⅛ cents a pound, or $80 to $102 a short ton. The quotations on lump alum were fairly constant at 4 to 4¼ cents up to May, when an increase to 4½ to 5 cents was made. This price remained steady till November, when it dropped to 4 to 4½ cents. Ground alum at the first of the year was quoted at 4⅛ to 4⅜ cents, but prices rose to 4⅝ to 5⅛ cents about the middle of May and remained stationary until the last of September, when they began to drop, and reached 4$\frac{1}{10}$ to 5 cents at the end of 1917.

---

[1] Eng. and Min. Jour., vol. 103, p. 880, May 19, 1917.
[2] Min. Jour. (London), vol. 116, p. 129, Mar. 3, 1917.
[3] Aluminum industry in 1917: Metal Industry, vol. 16, p. 21, January, 1918.

Aluminum sulphate is made at 24 plants, 7 of which are at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum sulphate produced in the United States in 1917 was 178,738 short tons, of which 4,947 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulphate which entered the market, 173,791 short tons, was greater than the quantity in 1916 by approximately 18 per cent, and the total domestic production increased about 16 per cent. The price reported by makers of aluminum sulphate for the 1917 output averaged $32.15 a short ton. Market quotations for low-grade aluminum sulphate ranged from a low of 2 cents to a high of 4 cents a pound, or $40 to $80 a short ton. Low-grade aluminum sulphate was quoted at 2 to 2½ cents a pound until October, when quotations rose to 2 to 3½ cents, but fell to 2 to 3 cents during the second week of November, and closed at 1¾ to 2¼ cents a pound at the end of the year.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at 3 plants in 1917, and the total output reported to the Geological Survey was 4,702 short tons, valued at $311,900, or approximately $66 a short ton. Market quotations on aluminum chloride remained stationary throughout the year at 4 to 4$\frac{1}{10}$ cents a pound, or $80 to $82 a short ton.

Alum and aluminum sulphate produced in the United States and aluminum salts imported, 1913–1917.

Year.	Production.						Imports.[a]	
	Alum.			Aluminum sulphate.				
	Quantity (short tons).	Value.	Price per ton.	Quantity (short tons).	Value.	Price per ton.	Quantity (short tons).	Value.
1913......	9,605	$312,822	$32.57	157,749	$2,977,708	$18.88	2,702	$66,549
1914......	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028
1915......	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320
1916......	27,257	1,177,881	43.21	153,860	4,410,741	28.67	1,247	68,660
1917......	19,714	1,017,083	51.60	178,738	5,746,427	32.15	507	39,088

[a] Includes alumina, aluminum hydrate or refined bauxite, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground.

BAUXITE ABRASIVES.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, exolon, and lionite, are made by fusing bauxite in an electric furnace. These products are sold in the form of powders, cloth, grinding stones, and wheels of various shapes for a multitude of uses.

The total marketed production of artificial abrasives made from domestic bauxite in 1917 was 48,460 short tons, valued at approximately $6,970,000, or about $144 a short ton. This is an increase over the production in 1916 of 58 per cent in quantity and of 200 per cent in value. The average value is deceptive, however, in that the prices received for the product depend on many factors, among which hardness, size of grain, degree of finishing, and many others may be mentioned.

HIGH-ALUMINA REFRACTORIES.

There are two classes of high-alumina refractories now on the market. What are commonly called bauxite brick are made by mixing various proportions of calcined bauxite or high-alumina clay with a bonding material such as fire clay, sodium silicate, or lime. Refractories of this character are being made by the Laclede Christy Clay Products Co., the Harbison Walker Refractories Co., Charles Taylor & Sons, and the Massillon Stone & Fire Brick Co. Not all the refractories made by these companies are sold as bauxite brick, and in fact some do not contain bauxite. The other class of high-alumina refractories consists of those made by the electric fusing of bauxite. These are manufactured by the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns. No figures are now (March, 1918) available to show the production of high-alumina refractories, though it is known that at least 2,313 long tons of bauxite was consumed in making refractories.

PLATINUM AND ALLIED METALS.

By James M. Hill.

USES OF THE PLATINUM METALS.

In discussing the uses of platinum in war it is not practicable to confine the discussion to that metal alone, for several metals of the platinum group are useful in war and must be considered together. These metals are platinum, iridium, palladium, rhodium, osmium, and ruthenium. The first four named are of commercial and military value; the last two are, so far as known, of little commercial value. The natural alloy of osmium and iridium, that is called osmiridium or iridosmine, is used commercially in a small way.

Pure platinum is required by the Government in very large quantities for use in the "contact process" of making sulphuric acid and for use at the new plants erected for the fixation of nitrogen. It is needed also for making utensils and apparatus at a great number of chemical laboratories, which control our whole industry. Finally, large quantities of platinum and iridium are required for all kinds of electrical equipment.

The so-called platinum used in electrical work is an alloy of platinum and iridium, and the alloy used for some work may carry as high as 50 per cent of iridium. Each telephone and telegraph instrument has platinum contacts; every high-grade magneto for an airplane, automobile, motor boat, or gas engine has from two to six contacts of platinum; and the multitude of contacts on telephone switchboards and the relay instruments of both telephone and telegraph lines are of platinum. For some purposes in electrical work satisfactory substitutes for platinum have been found and are being used; for other purposes substitutes will probably soon be used; but for many high-duty electrical contacts no satisfactory substitutes have yet been found.

Pure iridium is apparently of little commercial use. It is employed principally as a hardening element in the platinum-iridium alloys used in the electrical industry and by jewelers. Jeweler's platinum contains an average of 10 per cent of iridium, though some alloys that run as high as 15 per cent of iridium are used for certain work. Therefore, every 100 ounces of platinum used in the jewelry trade contains 10 ounces of iridium, to produce which it is necessary to obtain and refine approximately 200 ounces of Russian or 630 ounces of Colombian crude platinum. The alloys used in the electrical industry contain from 15 to 50 per cent of iridium, and the average alloy used in electrical work doubtless contains 20 per cent of iridium. To obtain 100 ounces of electrical platinum it is therefore necessary to refine 400 ounces of Russian or 1,260 ounces of Colombian crude platinum.

Palladium is employed chiefly in making palladium-gold alloys, which are now extensively used in dentistry and to some extent in the jewelry and chemical industries. Palladium may be considered valuable as a war metal to the extent that it replaces platinum in dental and jewelry work, for to that extent its employment releases platinum for military uses.

Rhodium is of little commercial use, being employed principally in making rhodium-platinum alloys, which form one element in thermocouples made for the electrical control of heat.

Apparently there is little or no market for osmium, though a suggestion was made in 1913 that it be used in place of iridium for hardening platinum. This suggestion has not been adopted, however, perhaps because of the danger of handling osmium under temperatures at which it will oxidize.

To summarize: Platinum, iridium, and palladium are essential for the conduct of the war; platinum, principally for the chemical industry; iridum, chiefly for the electrical industry; and palladium, for the dental industry, in order that more platinum may be released for chemical work.

SUPPLY.

Practically all the platinum metals in the world's supply have come from placer mines—deposits of gravel and sand in which the metals are found in grains and nuggets and are cleaned from waste material by water. Platinum was first recognized as a new mineral in material found in the Choco district, Colombia, South America; later it was identified in the gold placers of the Ural Mountains, in Russia, and it has since been found at a number of other places.

Duparc [1] states that the known Russian deposits, if mined at the pre-war rate, can last only 12 years. The Australasian deposits, in Tasmania, New South Wales, and New Zealand, have made small additions to the world's supply, but the deposits now known in these countries are not capable of supplying a hundredth part of the world's demand, and some of them are reported to be nearly exhausted. The deposits in Borneo have been worked, but they seem to be small. The deposits in North America appear to be capable of yielding some increase, but do not hold out much promise of a large output. The Spanish deposits give some promise, but are apparently not large. South America, especially Colombia, possesses a considerable reserve, and more scientific working of the deposits will unquestionably add to the world's supply. The search for new platiniferous fields in the world has not yet been highly successful. Little, however, is known of the possibilities of the Siberian placer fields.

In 1916 it was estimated [2] that the total world's supply of platinum metals was approximately 5,000,000 ounces. This estimate was based on certain assumptions and was not checked by an extensive survey of the literature on platinum. Thanks to Prof. James Lewis Howe, of Washington and Lee University, who has gone through the literature thoroughly, it is now possible to revise this estimate, and, happily, the revision shows larger resources. Prof. Howe's figures,[1] which appear to be essentially correct, indicate the total world production of platinum shown in the following table:

---

[1] Duparc, L., Le platine et les gîtes platinifères del l'Oural: Soc. ing. civils France Mém. Bull. janvier-mars, 1916, p. 48.

[2] Hill, J. M., Platinum and allied metals in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 1, 1917.

Estimated total production of crude platinum in the world to January, 1917, in troy ounces.

	Minimum.	Maximum.
Russia	7,115,482	10,128,308
Colombia	700,000	735,000
Borneo	175,000	200,000
New South Wales and Tasmania	9,000	10,000
Canada	9,000	10,000
United States	10,000	12,000
	8,018,482	11,095,308

The total supply of platinum metals in the world is probably more than 10,000,000 ounces, of which about 1,000,000 ounces of platinum and 400,000 ounces of other metals of the platinum group are now in the United States.

During the war the United States has not been receiving so much platinum as is normally consumed here. New industries and machines that require platinum have been built at a much faster rate, and the stock of platinum metals available for use during 1918 is evidently small and is constantly growing smaller.

The available supply of platinum metals can be increased somewhat by establishing a stable market at prices high enough to induce miners to save platinum and to stimulate imports of the metal—a step that has been taken by fixing the maximum price at which platinum can be imported at $105. The other means available is to husband the present supply of platinum metals. The supply is so short and the demand for essential war industries is so great that it may become necessary to commandeer stocks of partly manufactured platinum jewelry to meet the demand, though it is hoped that judicious administration of the metals already commandeered may obviate the necessity of such drastic action

The shortage was considerably relieved by the receipt, late in 1917, of about 21,000 ounces of platinum from Russia, consigned to the Secretary of Commerce. This shipment was immediately commandeered by the War Department for Government use.

DOMESTIC PRODUCTION.

CRUDE PLATINUM.

Crude platinum was produced in Alaska, California, Oregon, and Washington in 1917. Buyers and refiners report purchases of 605 ounces from producers in these States, which, at the average price ($90 an ounce), would have a value of $54,450. Incomplete returns from placer mines that produce crude platinum indicate that the production in 1917 fell off about 100 ounces from that of 1916, when it was 710 ounces. In view of the high prices for crude platinum in 1917 this decrease is rather difficult to understand, but part of it may be due to the fact that some of the miners held their platinum for higher prices.

---

[1] Personal letter to J. M. Hill.

Reports received from refiners indicate that 31,921 ounces of foreign crude platinum were refined. This figure does not include the 21,000 ounces of Russian crude received in December and not refined in 1917. Most of this material came from Colombia; the rest mainly from British Columbia, Java, and Russia.

REFINED PLATINUM.

Reports received from refiners of platinum, gold bullion, nickel, and copper indicate that 38,831 troy ounces of refined new metals of the platinum group were recovered, of which about 7,384 troy ounces are believed to be of domestic origin.

New platinum and allied metals recovered by refiners, 1915–1917, in troy ounces.

Year.	Platinum.	Iridium.	Iridosmine-osmiridium.	Palladium.
1915	6,495	274	355	1,541
1916	24,518	370	315	2,885
1917	33,009	210	833	4,779

Dealers and refiners reported sales in 1917 of 72,186 ounces of secondary platinum metals derived from refining scrap and sweeps. The figures that make up this total probably represent some duplication, as the same metal may be handled as scrap several times in a year. The large increase in the sales of scrap metals indicate clearly that, owing to the greatly decreased imports of crude platinum and the high prices paid for scrap, much attention was given to the collection and refining of all kinds of scrap containing platinum metals.

Secondary platinum and allied metals sold, 1915–1917, in troy ounces.

Year.	Platinum.	Iridium.	Palladium.
1915	42,149	863	958
1916	45,156	1,535	1,284
1917	59,007	9,832	3,347

WORLD'S PRODUCTION.

Statistics of the world's production of platinum and allied metals are at best estimates, though they are derived from the most reliable information obtainable. The statistics given in the table below are believed to be fairly accurate, though the figures for Russia are open to question, some estimates of the Russian production in 1917 being as high as 100,000 ounces.

Estimated world's production of crude platinum, 1910–1917, in troy ounces.

Country.	1910	1911	1912	1913	1914	1915	1916	1917
Borneo and Sumatra	200	....	....	200	(*a*)	(*a*)	(*a*)	(*a*)
Canada	30	30	30	50	30	100	60	80
Colombia	10,000	12,000	12,000	15,000	17,500	18,000	25,000	32,000
New South Wales and Tasmania	332	470	778	1,500	1,248	303	222	(*a*)
Russia	275,000	300,000	300,000	250,000	241,200	124,000	63,900	50,000
United States	390	628	721	483	570	742	750	605
	285,952	313,128	313,529	267,233	260,548	143,145	89,932	82,685

a No basis for estimate.

IMPORTS.

The imports of platinum and allied metals for consumption in 1917, exclusive of the 21,000 ounces of Russian platinum received in December, which do not appear in the reports of the Bureau of Foreign and Domestic Commerce for 1917, were about 57 per cent of the imports in 1916 and about 25 per cent of the pre-war imports.

Platinum and allied metals imported for consumption in the United States, 1916–17.

Metal.	1916		1917	
	Quantity (troy ounces).	Value.	Quantity (troy ounces).	Value.
Platinum or crude platinum and unmanufactured products, ingots, bars, sheets, wires	53,522	$3,138,087	30,207	$2,408,188
Platinum, manufactured products, vases, retorts, etc.	(a)	21,872	(a)	1,347
Iridium	3,346	250,705	3,619	378,678
Osmiridium	414	17,241	259	25,456
Osmium			400	23,359
Palladium	6,513	282,910	1,239	117,192
	63,795	3,710,815	35,724	2,954,220

[a] Quantity not given.

Platinum imported into the United States, 1916 and 1917.[a]

	Unmanufactured.		Ingots, bars, etc.		Manufactured products, vases, etc.	Total value.
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.		
1916.						
France	26	$1,841	2,006	$111,068	$16,471	$129,380
Chile	686	55,412	15	800	269	56,481
Netherlands	21	1,604	106	4,941	1,818	8,363
Norway			120	6,280		6,280
Spain	7	311	46	2,065		2,376
Peru	7	475				475
England	15,256	733,198	9,475	469,815		1,203,013
Canada	42	2,599	464	36,164	332	39,095
Panama	92	6,560				6,560
Mexico	93	6,231	11	489	33	6,753
Brazil	221	19,797				19,797
Colombia	24,774	1,677,805				1,677,805
Venezuela	11	698				698
Australia			5	243		243
	41,236	2,506,531	12,248	631,865	18,923	3,157,319
1917.						
France	192	20,422	1,705	143,162	80	163,664
Netherlands					254	254
England	2,044	144,570	1,570	102,763		247,333
Canada	46	3,792	420	37,495	48	41,335
Panama	38	2,629	5	470		3,099
Mexico	9	749	29	3,000		3,749
Brazil			3	300		300
Chile	83	6,800				6,800
Colombia	23,445	1,893,922	438	32,193		1,926,115
Venezuela	174	14,136				14,136
Dutch East Indies	49	4,430				4,430
China	66	3,940				3,940
	26,146	2,095,390	4,170	319,383	382	2,415,155

---

[a] Does not include platinum manufactures "Not specially provided for" in the tariff act, upon which a duty of 50 per cent is imposed.

The tables show that the imports from Europe have continued to decline and that the great bulk of those for 1917 came from South America. The imports from China are probably Russian platinum. The platinum imported from Dutch East Indies is presumably a by-product recovered by the tin dredges and may be an accumulation of several years' work.

MARKET AND PRICES.

REFINED METALS.

The quoted price of refined platinum in the New York market was $80 to $82 a troy ounce in January, 1917, but it increased to $102 to $105 in February and remained nearly stationary throughout the year. The average price for the year was $102.80 a troy ounce.

Average prices of refined platinum per troy ounce in the New York market, 1913–1917.[1]

1913	$44.88	1917: June	$104.75
1914	45.06	July	103.88
1915	49.63	August	104.55
1916	83.40	September	104.13
1917: January	87.83	October	104.00
February	103.75	November	104.52
March	103.33	December	104.38
April	103.77		
May	105.00	Average	102.82

After the War Department had commandeered all crude and refined platinum on March 2, 1918, a maximum price of $105 an ounce for all imports was set by the War Industries Board.

Refined palladium was quoted at $70 to $85 a troy ounce at the beginning of 1917, but prices advanced continuously throughout the year, being $115 to $125 for the period from August to November and reaching a maximum of $130 to $135 the last of December. Refined iridium was apparently sold only by special bargaining, and no very definite information is available concerning its price. Apparently $110 was the nominal quotation in January, but sales in the last months of 1917 are said to have been made at $180 to $185 an ounce.

The prices reported to the United States Geological Survey by refiners of the platinum group of metals varied considerably in 1917. In the following table fair average prices are given, and these prices have been used by the Survey in all computations.

Average price per troy ounce of refined metals of the platinum group, 1914–1917.

Metal.	1914	1915	1916	1917
Platinum	$45	$55	$84	$103
Iridium	65	83	94	150
Iridosmine	33	35	45	80
Palladium	44	56	67	110

---

[1] Eng. and Min. Jour., vol. 105, No. 2, p. 51, 1918.

No prices of osmium, rhodium, and ruthenium are available.

In England the platinum market is under control of the Government, for which Johnson, Matthey & Co. are the buyers. The buying price was 200 shillings ($48.67) an ounce and the selling price was 220 shillings ($53.53). On February 10, 1918, the prices were revised to 18 pounds sterling ($87) to 20 pounds sterling ($97) an ounce, a little below the prices ruling in the United States.

CRUDE PLATINUM.

United States.—The miners of California and Oregon received from $43 to $100 an ounce for their crude platinum in 1916. In 1917 the price of crude platinum in the United States ranged from $59 to $100 and averaged about $90 an ounce, which is the price that has been used by the United States Geological Survey in all computations. The principal buyers of crude platinum in the United States are:

American Platinum Works, Newark, N. J.
Baker & Co. (Inc.), Newark, N. J.
Belais & Cohn, 13 Dutch Street, New York, N. Y.
Pacific Platinum Works, Los Angeles, Cal.
R. & H. Platinum Works, 100 William Street, New York, N. Y.
Shreve & Co., San Francisco, Cal.
H. A. Wilson Co., Newark, N. J.

Colombia.—The price of crude platinum in Colombia in 1917, as the Survey is informed, ranged from $80 to $102 an ounce, the average price for the year being nearer the higher than the lower figure. Colombian crude platinum is estimated at 84 to 85 per cent fine.

Russia.—It is impossible to give any estimate of the prices paid for crude platinum in Russia. In March [1] it was reported that the miners were not satisfied with $80.36 an ounce, the price fixed by the Government. Later it was reported [2] that sales had been made at as high as $107.80 per ounce of crude metal 83 per cent pure.

NOTES ON PLATINUM DEPOSITS.

UNITED STATES.

GENERAL CONDITIONS.

A report on field work done in 1917 by the United States Geological Survey on the platinum deposits of California and Oregon is now in preparation. A summary of this report is given in a press bulletin [3] of the Survey, as follows:

> The important facts regarding the occurrence of platinum in California and Oregon are their widespread distribution and their lack of concentration in high value at any particular locality. In most placers the proportion of the platinum metals to the gold is very small. At one placer where large quantities of gravel were being handled the proportion of platinum to gold was about one-tenth of 1 per cent by weight. In a few small operations the proportion of platinum was reported to be equal to the gold, and in still fewer it was reported to be more than the gold.
>
> The problem of increasing the production of the platinum metals is closely involved with the production of placer gold and may be resolved into the problems of saving a larger proportion of platinum from the ground now mined and of finding new productive areas.

---

[1] Eng. and Min. Jour., vol. 103, p. 913, May 19, 1917.
[2] Idem, p. 1175, June 30, 1917.
[3] U. S. Geol. Survey Press Bull. 356, February, 1918.

DREDGING.

The modern dredge, which is capable of handling as much as 200,000 cubic yards of gravel a month, has become a highly efficient tool, but it is capable of still further improvement. If the gravel is clean and comparatively free from sediment, the dredge recovers most of the gold and platinum from the gravel that is handled, but if a large amount of fine mud or sediment is mixed with the gravel, it is not so effective.

By careful experiment one dredge operator estimated that his dredge has been losing 4¾ ounces of platinum a month. A dredge working in more favorable ground probably loses less, but the losses seem to have been studied in detail at only a few localities. The limit in methods of improvement must be found at the critical point where the cost of the improvement offsets the increase in returns. New methods or apparatus must add to the income or be abandoned. Where dredges must work rapidly in order to handle a large "yardage" the difficulties of making a great output of metal are increased, but the introduction of improvements like the jig and the elimination of as much barren material as possible from the sluicing apparatus will probably save a higher percentage of fine gold and platinum. It therefore seems that more efficient methods may yield some increase in the quantity of platinum recovered.

The chief problem is to find new ground for dredging. There are areas in northern California and southern Oregon that seem to be favorable for successful dredging, but it will be difficult to find ground as favorable as that now being dredged. Good ground can be found only through close investigation by those who are most familiar with dredging.

DRIFT MINING.

Old stream channels that are buried hundreds of feet beneath the lava on the western slopes of the Sierra Nevada formed the feeders of the gravels in the areas along the foothills that are now being dredged. These buried channels are mined by drifting or tunneling under the lavas, bringing the gravels to the surface, and recovering the placer gold. Some of these old channels carry considerable platinum aside from the gold, and at a few places attempts are being made to mine them more extensively. Drift mining on a scale approaching that of dredge mining would doubtless recover an equivalent quantity of the platinum metals.

HYDRAULIC MINING.

The hydraulic mines in northern California and southern Oregon are producing some platinum along with the gold. The proportion of the value of the platinum to that of the gold produced at some of these mines is about 1 to 20. Unmined gravel deposits along streams in this area contain platinum as well as gold and should yield a considerable quantity of the platinum metals. The main problem at most of these deposits is to get sufficient water for mining, and any adequate investigation of them must determine not only the quantity of gold and platinum in the gravel but also the quantity of water available for mining. These deposits can be successfully mined only by bringing water to them from considerable distances—several miles, at least. Large reserves of the platinum metals are probably locked up in these unmined gravels, but they can be recovered only when the cost of mining is reduced by more favorable conditions.

BEACH SAND MINING.

The beach sands along the coast of Oregon and California have long yielded gold and platinum. The sands mined include not only those of the present beaches, but those of old beaches that, through changes in the relation of the land to sea level, now stand about 200 feet higher than the present beaches. The sands of the present beaches were in places so rich that in the early days they caused one of the great stampedes recorded in the history of California. That was the time when the metal which had accumulated by long-continued wave action was ready to be gathered in by the miners. Even yet the hard winter storms bring metal to the miners, who are engaged every winter in a small way in working these sands. The outfit of these miners is generally simple. The long tom forms its foundation. At some places a small power plant is employed. The winnings of individual workers have been good.

The problem of mining the black sands of the beaches has been an alluring one, and many attempts have been made to mine on a large scale both the sands of the present beaches and those of the elevated beaches. A successful method of mining these sands must be based on a thorough prospecting of the material to be handled, which varies in richness not only vertically, layers of black sands alternating with layers of barren sands, but horizontally. In any method of mining these sands many a streak of lean must be handled with the fat.

The prospecting of these sands is difficult. The average value of the ground can be determined only by closer attention than is usually given to it. Similar sands occur in Australia, and similar difficulties of prospecting and mining have been encountered there. Dredging, hydraulic mining, and drifting have been so perfected as to handle large quantities of material successfully, but no reliable method has yet been found to handle these beach sands, though during the season of 1917 preparations were being made at several places for working them on a large scale.

SUMMARY.

The possibility of increasing the production of the platinum metals, then, depends on improvements in the methods of saving now used, on the extension of these methods to areas that are known to contain these metals but that have not yet been mined, and on the discovery of new productive ground in northwestern California and southwestern Oregon, where the prospects seem to be good. Streams that carry insufficient gold and platinum to pay for mining at the prices formerly prevailing might now yield a profit. Streams that drain areas of serpentine would seem to be particularly favorable for prospecting. At no place are the platinum metals concentrated in large quantities. Being rarer than gold, they are harder to find than gold. Iridium is in great demand, and the fact that it forms 10 to 40 per cent of the platinum metals in nearly all the placer deposits in the United States is a special incentive to the search for more of them.

The elimination of litigation and the equitable settlement of questions regarding surface rights and underground rights in drift mining and regarding the distribution of water for irrigation, power plants, and mining might also increase the output. The present price of the platinum metals, which is higher than that of gold, does its share in encouraging production.

ALASKA.

During 1917, 81 ounces of platinum were saved at Alaska platinum mines—66 ounces at mines on Seward Peninsula and 15 ounces at mines in the Copper River country.

The place at which the largest production of platinum was made on Alaska was Dime Creek, where 17 placers were in operation. On this stream about 1 ounce of platinum is recovered to every $5,000 worth of gold. Some platinum is also produced on Bear and Sweepstakes creeks, in the same general vicinity.

From placers on Boob Creek, in the Tolstoi district, lower Yukon, 30 ounces of platinum were taken during 1917. Platinum occurs in the gravels of Kahiltna River, a branch of Susitna River, about 50 miles northwest of Anchorage. These gravels are now being tested for platinum. A small quantity of platinum was taken from the beaches of Kodiak Island in 1917.

CALIFORNIA.

Only about 460 ounces of crude platinum produced from California placers appears to have been sold to refiners in 1917, but more crude platinum may have been produced than was sold, though at this time (Mar. 28, 1918) the final figures showing the mine output are not available. As usual, the largest output was made by the dredges in Butte, Yuba, Calaveras, and Stanislaus counties. Some platinum was won in Trinity, Siskiyou, and Humboldt counties, the largest output in these counties being won by dredging at Junction City.

NEVADA.

The Boss mine, near Goodsprings, Nev., was extensively worked in 1917, according to the published report of the company dated January 15, 1918. Shipments were made of 442.53 tons of copper-gold-platinum ore, which carried 107 ounces of platinum and 400 ounces of palladium. Early in 1917 this ore was refined in New Jersey, but during the summer it was refined at the plant of the Palau Metals Co. near Los Angeles, then just completed.

OREGON.

The beach deposits near Bullards and Marshfield were the largest producers of platinum in Oregon, reporting a total of over 65 ounces won in 1917. A little platinum was saved by the dredges near Sumpter and in the hydraulic and sluice mines near Waldo and Kerby.

WASHINGTON.

Refiners reported the purchase of several ounces of platinum produced in Washington, which may have come from the beach deposits, from South Fork of Lewis River, or possibly from the Tulameen district in British Columbia.

WYOMING.

The Rambler mine, near Holmes, Albany County, Wyo., continues to produce platinum and palladium bearing copper ores. During the year about 350 tons of concentrates were refined, which carried considerable palladium and about one-third as much platinum. It is reported that recent work at greater depth in the mine has disclosed a new ore body that carries both platinum and palladium in workable amounts.

OTHER COUNTRIES.

CANADA.

The Tulameen district in British Columbia produced at least 75 ounces of platinum in 1917 and probably nearer 90 ounces. Some new platinum placers are said to have been found farther north in the Rockies, one of which appears to be a deposit that at the present prices of platinum might be profitably worked.

COLOMBIA.

The production of platinum in Colombia has increased steadily for several years and our imports from that country in 1917, as shown by refiners' reports, were 31,737 ounces of crude platinum. The American interests, which are operating one dredge on the Condoto, hope to have in operation during the summer of 1918 a second dredge, which should materially add to the Colombian output. If the prices now paid for Colombian crude platinum, about $102 an ounce in New York, are maintained, we can expect a considerably larger production in Colombia, for at those prices the native labor will be content to remain in the platinum country instead of returning to the gold region, in which they prefer to live. No word has yet reached the Survey of any large undertakings in this promising field, though it is reported that a new company has been organized in England for working the Opogoda properties and that the old Certigue or Quito properties on the Upper Atrato are being refinanced.

RUSSIA.

Little can be said of the Russian platinum fields. Engineers returning from Russia report that none of the dredges are working and that it will take some time to put them in shape for operation. The platinum now produced is won by hand methods, and under the chaotic conditions that have prevailed in Russia not much platinum can be expected from that country for some time.

ARSENIC.

By Joseph B. Umpleby.

CONDITION OF THE INDUSTRY.

The production of arsenic or arsenious oxide in the United States in 1917 amounted to 6,151 short tons, valued at $1,118,313, an increase over 1916 of less than 3 per cent in quantity and of more than 101 per cent in value. The value of the output is somewhat uncertain, however, as in some returns it represents the value f. o. b. destination in carload lots and in others the value at the reduction plant. Throughout, however, the value reported by the producers is much lower than that quoted in the trade journals.

Nearly all the output in 1917 was recovered as a smelter by-product. One plant only, at Brinton, Va., began late in the year to mine and treat ore primarily for its content of arsenic. For this reason it is impossible to distribute the production according to the source of the ore. In 1917, as in previous years, however, Butte, Mont., and Tintic, Utah, have been important sources of arsenical ores. At Butte the sulpharsenite of copper, enargite, is, after chalcocite, the most abundant valuable mineral in the deposits. It has been estimated that in smelting these ores 14,000 or 15,000 short tons of arsenic trioxide is liberated each year.[1] Of this amount only a small part is recovered, but with the addition of a new Cottrell treater for flue dust at Anaconda the quantity of arsenic saved will be greatly increased. It is thought that this installation will be in operation by January, 1919.

Arsenic is found in most of the ores of the Tintic district, and large quantities of it are released in their treatment. The arsenic-bearing minerals are enargite and tennantite, together with tetrahedrite and famatinite, in which arsenic replaces part of the antimony.

The smelter at Tacoma, Wash., recovers large quantities of arsenic, which presemably comes from ores mined in Washington, Oregon, British Columbia, and Alaska. Indeed, arsenic is present in most of the ores mined in the Western States and large quantities of it escape through the flues of the smelters that reduce the ores. It has been estimated that "at least 25,000 tons of white arsenic could be saved each year as a by-product."[2] The limiting factors in a prompt response of production to a suddenly increased demand are the time required to install additional collecting equipment and the assurance of a continued demand sufficient to warrant the expense of the installation.

---

[1] Hess, F. L., U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 958, 1916.

[2] Idem, p. 960.

The unusual demand for insecticides incident to increased gardening led the Government to place the industry under license late in the year. Early in 1918 the Food Administration, after exhaustive investigation during the later part of 1917, fixed a maximum price of 9 cents a pound to be charged by producers for white arsenic in carload lots delivered anywhere in the United States. Half a cent a pound additional is permitted for shipments in less than carload lots.

DEVELOPMENT DURING 1917.

During the year 1917 the American Metals Co. (Ltd.) resumed production at its smeltery, the Compañía de Minerales y Metales, at Mapimi, Mexico, and the Chipman Chemical Co. reopened the old arsenic plant at Brinton, Va. Preparations were also made for recovering the arsenic from a large quantity of accumulated flue dust at Great Falls, Mont., and progress was made on the installation of a new Cottrell treater at Anaconda.

The Mexican product is largely imported into the United States, and most if not all of it comes from the Mapimi reduction works, as is shown by the increased imports recorded from Mexico after that plant was opened. The arsenic at this plant is a by-product from the smelting of silver-lead ore originating at the company's Ojuela mine, in the State of Durango. Additional capacity for collecting arsenic from the flue dust at Mapimi is being provided and is expected to be ready for operation sometime during the summer of 1918.

The Brinton deposit, in Virginia, described by Hess [1] contains ore that is valuable principally for its content of arsenic.

During the year the old producers maintained about the same rate of output as in 1916.

The outstanding feature of the year's development was the large increase in the requirements of the manufacturers of insecticides. In December, 1917, in response to a detailed canvass by C. W. Merrill, of the Food Administration, the manufacturers of insecticides estimated that, in preparing for the growing season of 1918, they needed 6,900 short tons of arsenic. This, together with 1,000 tons estimated as the requirement of the manufacturers of sheep dip, nearly equals the total annual supply from production and imports for each year since 1913 and exceeds the total supply for each previous year. Yet under normal conditions from one-third to one-half of the arsenic consumed in the United States is used by the manufacturers of glass. The increased demand for insecticides is doubtless in large part a direct result of the campaign for home gardens. Most of this is probably a necessary outcome of existing conditions, but it seems likely that much more than usual is wasted, because of the overzealousness of the novice in combating garden pests.

PRODUCTION.

Arsenic was produced in 1917 at seven plants operated by four companies. The table below shows the production of arsenic from the opening of the first plant at Everett, Wash., in 1901, to the end of 1917.

---

[1] Hess, F. L., The arsenic deposits of Brinton, Va.: U. S. Geol. Survey Bull. 470, pp. 205-211, 1911.

White arsenic (As_2O_3) produced in the United States, 1901–1917.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1901	300	$18,000	1910	1,497	$52,305
1902	1,353	81,180	1911	3,132	73,408
1903	611	36,691	1912	3,141	190,757
1904	36	2,185	1913	2,513	159,236
1905	754	35,210	1914	[b] 4,670	313,147
1906	737	63,460	1915	[c] 5,498	302,116
1907	1,751	163,000	1916	[d] 5,986	555,187
1908	([a])	([a])	1917	6,151	1,118,313
1909	1,214	52,946			

[a] Only two firms produced arsenic in the United States in 1908, so that the figures can not be published without disclosing confidential returns.

[b] This quantity includes 200 tons of crude arsenic trioxide carrying about 97.5 per cent As_2O_3.

[c] This quantity includes 353 tons of crude arsenic trioxide carrying about 97.5 per cent As_2O_3.

[d] This quantity includes 152 tons of crude arsenic trioxide carrying about 97.5 per cent As_2O_3.

The refined arsenic produced is reported to be above 99.5 per cent As_2O_3.

The small increase in the domestic production of arsenic and the great increase in its value in 1917 are noteworthy features shown by the table.

IMPORTS.

The imports of white arsenic and arsenic sulphide, or orpiment, increased from 2,163 short tons in 1916 to 3,955 short tons in 1917, or nearly 83 per cent. This increase should be compared with a decrease of 32 per cent in 1916 and is due to the resumption of production in Mexico as well as to increased imports from Canada. The Mexican source of supply has already been mentioned on page 24. The Canadian output is derived as a by-product in the smelting of ores from Cobalt and adjacent silver deposits in northern Ontario.

Arsenic compounds imported and entered for consumption in the United States, 1909–1917.

Year.	Arsenic or arsenious acid (white arsenic, As_2O_3).		Arsenic and sulphide of, or orpiment.		Sheep dip.		Paris green and London purple.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
1909	445	$31,235	3,591	$272,493	1,574	$9,615	183,765	$20,370
1910	1,348	76,282	3,791	238,024	....	24,279	181,363	14,648
1911	1,921	116,948	2,175	127,375	....	20,642	126,191	4,972
1912	3,108	200,616	3,068	228,125	....	41,556	162,272	6,950
1913	1,519	133,597	3,182	276,849	....	40,036	99,692	4,431
1914	1,594	109,121	2,034	164,592	....	34,556	15,476	2,235
1915	1,400	113,677	1,783	154,099	....	19,916	21,056	4,069
1916	1,071	107,876	1,092	124,818	....	20,134	23,461	5,028
1917	1,178	264,534	2,777	410,341	....	15,848	48	189

It is impossible from information available to group the total imports by countries, because the source is recorded for only one of the two principal classes of material. The ports of entry, however, afford a fairly satisfactory idea of the source of the other principal class.

The table below shows that in 1916 about 87 per cent of the class listed as "arsenic and sulphide of, or orpiment," came from Canada, and that of the "arsenic and arsenious acid" 96 per cent entered through Buffalo and Michigan ports—presumably also from Canadian deposits. Similar figures for 1917 indicate approximately 42 per cent and 90 per cent, respectively, from Canada. The production from Mexico in 1916 was negligible, but in 1917 it amounted to nearly 57 per cent of the class designated as "arsenic and sulphide of, or orpiment." It is likely also that most of the arsenious acid entering through the port of New York came by coastwise boats from Mexico.

Arsenic imported into the United States in 1916 and 1917.

Arsenic and sulphide of, or orpiment.

Country.	1916.		1917.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Belgium	116	$18,647	14	$7,171
British Honduras	0.1	26	....	....
Canada	950	95,912	1,172	262,552
England	2	1,808	2	1,407
France	17	6,517	....	....
Germany	6	696	....	....
Japan	....	....	1	301
Mexico	1	1,212	1,588	138,910
	1,092	124,818	2,777	410,341

Arsenic or arsenious acid.

Port of entry.	1916.		1917.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Buffalo	986	$99,823	980	$215,776
Michigan	45	4,495	....	....
New York	40	3,558	113	26,193
Ohio	....	....	85	22,565
	1,071	107,876	1,178	264,534

PRICE.

The price of arsenic during any year is much more difficult to determine than that of metals which are produced in larger quantities and for which there is a wider market. A comparison of the quantity and value reported by the different producers shows a much wider discrepancy in the price received than is warranted by differences in freight rates from the several smelting centers to the eastern market. A similar comparison of figures recorded in the commerce reports for the several ports of entry reveals similar discrepancies. Also the "spread" between producer's price and the price on the New York market is far from a fixed percentage of the cost of arsenic to the jobbers.

The price per pound of white arsenic in New York in 1917, as quoted by the Oil, Paint, and Drug Reporter, ranged from 8 cents in January to 20 cents in May, June, and July, after which it fell, reaching 15½ cents in December. The average price paid to producers, however, seems to have been between 9 and 11 cents, and the maximum price paid to producers is understood to have been 16 cents.

OUTLOOK FOR 1918.

The deficiency in arsenic is not confined to the United States. In England and France prices even higher than those in the United States clearly reflect a shortage in the supply of arsenic, although both these countries are large producers of arsenic, England from the Cornwall deposits and France principally from the auriferous arsenopyrite deposits in the Department of Maine-et-Loire.

The extent to which arsenic may hereafter be used in preparing poisonous gases for use in trench warfare is not known, but it is believed that more poisonous constituents of gases are more readily available. The use of arsenic in weed-killing compounds is likely to increase to the limit of the supply. The shortage of labor available for keeping rights of way and cemeteries free of weeds is causing many inquiries concerning the uses of arsenic compounds for this purpose. In some of the Southern States arsenic compounds are used in killing trees preliminary to clearing land for agricultural use. These and many other demands for arsenic are likely to increase as long as there is a serious shortage of labor.

The present demand for arsenic consumes about 12,000 short tons a year, whereas the available supply in 1917 from both domestic production and imports was only to about 10,000 short tons. The supply in 1917, however, was much larger than in previous years. The average yearly supply from all sources for the period from 1911 to 1916, inclusive, was a little less than 8,150 tons. During 1918 the domestic production may be expected to increase and unless the output from Mexico and Canada finds another market the imports will also increase. On the other hand, the demand for arsenic will almost certainly increase and probably at a more rapid rate than production. It seems likely that a scarcity of arsenic will persist throughout 1918 and that the price will hold close to the maximum fixed by the Food Administration.

BISMUTH.

By JOSEPH B. UMPLEBY.

PRODUCTION.

The demand for bismuth, unlike that for most other metals, has not greatly increased during the war. There continue to be only two producers of bismuth in this country, so that the production may not be given, but it was very little in excess of that for 1916, and the wholesale price is understood to have been about 6 cents a pound lower. The bismuth produced in this country is almost entirely a by-product obtained in the refining of lead bullion. Market conditions have not heretofore justified the recovery of bismuth at many plants where it could be obtained from flue dust or bullion, and as the cost of mining and delivery to these plants is charged against other constituents of the ore, it is doubtful whether ore that is primarily valuable for bismuth will ever command a ready market in this country unless the use of the metal is greatly extended.

USES.

Little has been published relating to the uses of bismuth, but as it possesses the special property of expanding on cooling and of forming alloys of exceptionally low melting point, the following extensive quotation from a paper prepared by the Queensland Government geologist[1] is believed to be justified.

> Numerous useful alloys are made by fusing bismuth with other metals, such as copper, tin, lead, and antimony. A small amount added to copper makes this metal red-short, or brittle when heated, and an alloy made by melting one part of copper to two parts of bismuth expands considerably on solidification; while one part of copper fused with four parts of bismuth produces a red crystalline alloy. Small quantities added to lead give toughness without brittleness, and two parts of bismuth with three of lead has ten times the hardness and twenty times the tenacity of lead, while two parts of lead and one of bismuth makes a very fusible and ductile alloy. Antimony fused with bismuth produces an alloy which expands when changing from a molten to a solid state, and equal quantities of both in an alloy produces a greater expansion than any other metal on solidification. Bismuth with tin forms alloys which are very sonorous, and to produce this effect in a marked degree some of the many plate and bell metals are made with bismuth as part of their composition. One part of bismuth to twenty-four of tin forms a malleable metal, which becomes brittle as the amount of bismuth is increased. Mercury is capable of absorbing a large quantity of bismuth in the formation of amalgams. Two of mercury to one part of bismuth forms a pasty mass, while with four parts of mercury the amalgam is in a liquid state. In the latter condition the amalgam is used in silvering both mirrors and the interior of vacuum flasks, although another alloy containing two parts of mercury and one each of bismuth, lead, and tin is used for the same purpose.
>
> Bismuth is alloyed with two or more suitable metals to produce [a compound which will show] expansion when cooling down to a solid state, and which at the same time should be an easily fusble composition, the principal metals used in producing these two effects being lead and tin, with zinc, antimony, cadmium, and mercury as accessory constituents. In making solders the melting point can be lowered if bismuth is alloyed with them, and soldering can be effected under boiling water if the right proportion, as shown in the table, is present.

---

[1] Dunstan, B., Queensland mineral deposits (bismuth): Queensland Gov. Min. Jour., January, 1917, pp. 17-22.

Fusible bismuth alloys.

[Fusible below the boiling point of water, 212° F.

	Bismuth, melting point 520° F.	Lead, melting point 621.1° F.	Copper, melting point 1,981.5° F.	Tin, melting point 449.4° F.	Cadmium, melting point 609.6° F.	Mercury, melting point 37.7° F.	Antimony, melting point 1,166° F.	Melting point of alloy, °F.
Charpy's eutectic	8	5	....	2½	....	....	....	204°
Newton's metal	8	5	....	3	....	....	....	201°
D'Arcet's metal	8	4	....	4	....	....	....	199°
Rose's metal	8	8	....	3	....	....	....	174°
Onion's mercuric	8	5	....	3	....	1½	....	170°
Lipowitz's metal	8	5	....	2	1	....	....	150°
Lipowitz's mercuric	8	4	....	2	2	1	....	143°
Wood's metal	7½	4	....	2	2	....	....	140°
Guthrie's eutectic	8	3	....	3	2½	....	....	(1)
D'Arcet's mercuric	8	4	....	4	....	20	....	113°

[1] Very fusible.

The variations in expansion and contraction of bismuth alloys indicate that in making castings it is better, when convenient, to allow the metal to cool to a semifluid condition and to press instead of pour the metal into the molds, as then it is nearing its minimum contraction. Stereotype metal and other metals used in printing are only occasionally made up with bismuth as one of the constituents, but where rough usage is expected, or where firmness and sharpness is specially desired, no other metal produces these qualities so effectively as bismuth.

Bismuth is useful in the processes of steel tempering. The exact degree of heat required for the purpose can be fixed automatically by using baths of molten alloys containing bismuth, which can be made up of varying proportions and giving fixed melting points.

As stated already, the presence of bismuth in an alloy gives low fusibility combined with hardness and sharp definition. The addition of cadmium to the bismuth-tin-lead series further lowers the fusing point, while the addition of mercury brings the temperature of fusion down to its lowest limits.

Safety plugs for boilers are made of an alloy of which bismuth is one of the constituents. The automatic sprinklers or fire extinguishers placed in the ceilings of buildings are also made of a bismuth composition and are set in action when material in a room takes fire, the rise in temperature immediately melting the easily fusible bismuth plugs and causing jets of water to play all over the room.

Electric fuses are sometimes made of a bismuth alloy, and are so constructed that if too great a charge of current is passed through them the easily fusible wire melts. This causes a disconnection and prevents any damage to the instruments or appliances within the circuit.

Bismuth is extremely diamagnetic, that is, opposed to magnetic influence. Antimony is another diamagnetic metal and with bismuth forms the couple of a delicate thermopile, an instrument used for measuring by thermoelectric force, indicated by a galvanometer, extremely minute changes in the heat of metals.

Bismuth bronzes suitable for spoons, jugs, teapots, etc., are alloys made up of a number of metals and are said to be unoxidizable, to keep a good color, and to be easily polished. Two such bronzes are of the following composition, respectively: (1) Copper, 25 parts; nickel, 24; antimony, 50; bismuth, 1; (2) copper, 69; nickel, 10; tin, 15; zinc, 20; aluminum, 1; bismuth, 1.

Bismuth subnitrate is used in surgical operations, in porcelain painting, as a medicine, and as a cosmetic. In medicine the carbonate is used much more than the subnitrate, as it is very easily assimilated. The oxychloride of bismuth as a medicine is of special use as a preliminary to surgical operations on the stomach. Four ounces of this is taken and assimilated, after which the stomach and intestines are photographed by X rays, the whole of the outline of these digestive organs and their defects being clearly defined as a result of the sensitiveness of the bismuth to these rays. Bismuth salicylate, gallate, lactate, and other organic compounds are used as medicine and in surgical operations, but the demand for them is much smaller than that for the carbonate, subnitrate, and the oxychloride.

The oxide is used in porcelain painting and also in glass staining, the object of its introduction and also that of the subnitrate being to prevent certain substances producing color which otherwise are useful fluxes. In gilding porcelain the oxide or the subnitrate is mixed with 15 times its weight of gold, applied with a brush, and then fired. The subnitrate gives a colorless but iridescent glaze to porcelain and produces a yellow glaze when mixed with chromic oxide. The addition of 5 per cent of gold to the oxide makes a good copper-red glaze mixture, which has also the quality of producing a golden luster by reflected light. With less gold the color may be varied, and beautiful blue and violet shades can be produced by other proportions and manipulations of the same ingredients. In porcelain painting and enameling the bismuth compounds may be generally used as a flux for increasing the fusibility of other coloring oxides, and therefore become a vehicle for the oxides of manganese, chromium, and copper. Mixed with the oxide of antimony the subnitrate forms Merinee's antimony yellow, which is a good body pigment, and quite permanent.

IMPORTS.

The imports of bismuth in 1917 were somewhat less than in 1916, although greater than in 1915. Prior to the last decade the supply of bismuth in this country was almost entirely imported, but in recent years most of the imports have been displaced by the domestic product. The industry, however, is not a large one in this country, probably less than 250 short tons annually being sufficient to meet the demand.

The imports are shown in the following table:

Metallic bismuth imported and entered for consumption in the United States, 1906-1917.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1906	254,733	$318,452	1912	182,840	$316,440
1907	259,881	325,015	1913	117,747	213,257
1908	164,793	257,397	1914	90,505	165,208
1909	183,413	286,516	1915	44,362	108,288
1910	198,174	332,668	1916	76,723	195,975
1911	172,093	311,771	1917	69,250	142,300

The bismuth imported into the United States in 1917 came from England and from South American countries, but it is probable that much of the bismuth shipped to the United States was imported into the country to which it is credited in the following table. Bismuth is not produced in England, although much of the Australian ore is reduced there. Bolivia has been the world's principal source of bismuth in recent years, and it is likely that most of the imports from South America originated in that country.

Bismuth imported into the United States, 1917.

Country.	Quantity (pounds).	Value.
England	38,453	$103,684
Argentina	6,674	16,757
Chile	21,799	17,792
Uruguay	2,324	4,067
	69,250	142,300

SELENIUM.

By Joseph B. Umpleby.

For the first time in recent years more than two companies reported a production of selenium in 1917, so that figures may now be given. The output in 1917 was 39,630 pounds, valued at $70,000. The producing companies are the American Smelting & Refining Co., the Raritan Copper Works, and the United States Smelting, Refining & Mining Co.

Selenium, it is understood, was in demand in 1917, and the principal producing company reports that its output has been contracted for well into the future. This is in keeping with the fact that the value of imports for consumption of selenium and salts of selenium rose from $59 in 1915 and $302 in 1916 to $2,236 in 1917.

The shortage of imported manganese suitable for the glass industry has compelled the manufacturers of glass to seek a substitute, and it is reported that selenium has been found to be the most satisfactory.

Most of the selenium produced is a by-product in the electrolytic refining of copper.[1] It is the opinion of metallurgists that if market conditions warranted the domestic production would be greatly increased.

Uses.—Selenium is used to impart a red color in the manufacture of glass and enamel ware and to mask the green color in glass. Its most interesting uses, however, are based on its being a good conductor of electricity in the light and a poor one in the dark. Thus it finds use in measuring the Roentgen rays, in appliances for automatically turning on the light at night and for extinguishing the light in daytime, in wireless telegraphy, and in burglar alarms. Many electrical inventions are based on this property, but none have called for sufficient material to cause great increase in the demand.

Experiments have been made recently in vulcanizing rubber by selenium, but its high melting point, 217° C., discourages its use as a vulcanizer "for rubber, which is not capable of withstanding such a temperature."[2]

Selenium compounds have found a limited use in treating some of the so-called "incurable diseases."

Price.—Prices at the refinery ranged from $1.29 to $3 a pound, but as usual the price for small lots was much higher and ranged between wide limits, depending largely on the quantity purchased.

---

[1] A summary of published information concerning the occurrence of selenium in blister copper and in various ores is recorded by F. L. Hess in U. S. Geol. Survey Mineral Resources, 1914, pt. 1, pp. 971–972, 1916.

[2] Boggs, C. R., Vulcanization of rubber by selenium: Jour. Ind. and Eng. Chemistry, p. 117, February, 1918.

TELLURIUM.

By JOSEPH B. UMPLEBY.

There continues to be little market for tellurium and a correspondingly small production. Only two refiners, the Raritan Copper Works and the United States Smelting, Refining & Mining Co., reported a production in 1917.

Tellurium, like selenium, is a by-product from the electrolytic refining of copper. The domestic production is capable of large expansion if market conditions should warrant, as almost all blister copper contains recoverable quantities of tellurium. Much of this would be saved, if a demand existed, at prices of $1.50 to $2.50 a pound. In 1917 prices at the refinery averaged about $3 a pound, but a very small additional output would probably have flooded the market.

CHROMITE.

By J. S. Diller.[1]

COMPOSITION AND USES OF CHROMITE.

Chromium is one of the important war metals, being extensively used as an alloy to harden steel in the manufacture of munitions.

About a dozen minerals contain chromium, but chromite, often called chrome ore or chromic iron ore, is the only mineral of commercial importance as a source of chromium. Its theoretical composition is represented by the chemical formula $FeO.Cr_2O_3$, according to which it contains 68 per cent Cr_2O_3 (chromic oxide) and 32 per cent FeO (ferrous oxide). In nature, however, more or less of the chromium is replaced by aluminum or iron, so that the percentage of chromic oxide varies with the degree of replacement from more than 60 per cent down to less than 10 per cent. The value of chromite depends on the content of chromic oxide, and the price of any grade of ore is based on the percentage of chromic oxide that the ore contains. High-grade domestic ore contains 40 per cent or more of chromic oxide. Much of the domestic chromite is of low grade, although the greater portion of it is reported to be of high grade.

The principal present applications of chromite are for metallurgic use in the manufacture of ferrochrome to make munitions of war and for furnace lining in the form of crude ore or chrome brick. Several special steels, as automobile steel and airplane steel, contain chromium, but not all of them are of special importance in the war program.

The principal chemical uses of chromite are in the manufacture of bichromate of soda, bichromate of potash, chromic acid, and chrome alum, which are employed in the manufacture of dyes and pigments and for tanning leather.

For both metallurgic and chemical uses high-grade ores are much desired. Low-grade ores can be used to greater advantage in making the alloy ferrochrome than in making chemicals. This adaptability in the manufacture of ferrochrome renders it possible greatly to extend the production and utilization of the low-grade domestic ores.

SUPPLIES.

The available supplies are made up of domestic production and imports, as is shown in the following table:

Available supplies of chromite, 1913–1917.

Year.	Domestic production (long tons).	Imports (long tons).	Quantity available (long tons).
1913	255	65,180	65,435
1914	591	74,686	75,277
1915	3,281	76,455	79,736
1916	47.035	115,945	162,980
1917	43,725	72,063	115,788

---

[1] The statistics for this chapter were compiled chiefly by Miss H. M. Gaylord, of the United States Geological Survey.

The total available chromite in 1913 probably represents closely the demands for normal consumption. It is probable that in 1914 and 1915, however, in order to accumulate a stock on hand to meet war conditions, more was imported than was actually needed. With greatly increased demands in the last two years, both domestic production and imports have been greatly enlarged and the consumption has more than doubled.

Although the returns from producers of chromite in the United States in 1917 may not all have been received (March, 1918), it appears probable that the production was 43,725 long tons. In this connection the Geological Survey would like to emphasize the importance of each producer making a prompt report on his operations, as it is only with full cooperation that the Survey is in turn able to furnish accurate data necessary to the Shipping Board. Several thousand tons have been reported unsold. As the domestic production in 1916 was 47,035 long tons, there was apparently a considerable decrease in production in 1917.

DOMESTIC PRODUCTION.

GENERAL STATEMENT.

The domestic production in 1917, so far as may be judged from reports already received by the Geological Survey, was 43,725 long tons. It came mainly from California, where the output was more than 36,700 long tons. Oregon ranks second, with a production of about 6,700 long tons. Alaska produced nearly 1,000 tons, and the remainder, less than 300 long tons, came from Washington, Maryland, and North Carolina. The accompanying map of North America (fig. 1) shows approximately the distribution of the producing chrome mines and important deposits not only in the United States but elsewhere in North America. As a considerable number of supposed producers have not yet reported, it is possible that the total production may turn out finally to be somewhat greater. It seems probable that the total domestic production in 1917 was about 3,000 tons less than in 1916. If so, the decline deserves special consideration in view of the constantly increasing demand.

CAUSES AFFECTING DOMESTIC PRODUCTION.

To discover, if possible, the causes of decline in the production of chromite in 1917, the United States Geological Survey sent out a questionnaire to all the chrome producers on its list, asking for statements of the maximum possible production of the mine during the last quarter of 1917 and the actual shipments of chromite from the mine during the same period, the difference being the deficiency in production due to one or more causes, of which the following may be noted: Bad weather, poor roads in winter, lack of funds, lack of shipping facilities, especially lack of cars as the result of the freight embargo, low prices, and uncertainty of market, particularly for low-grade ore. The last two are the most potent causes affecting small producers.

PRICES.

Significant articles[1] have appeared recently in the mining journals concerning a higher and more equitable price to the man who mines

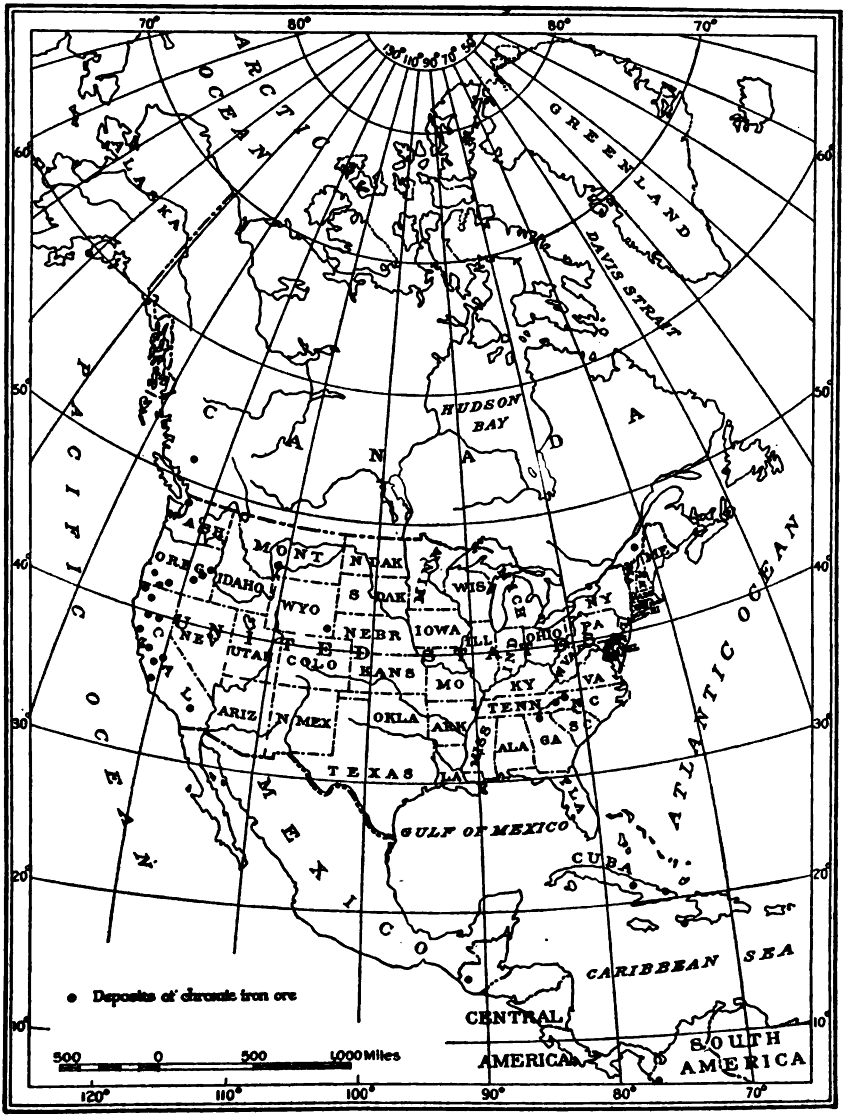

70°
80°
80°
70°
130 110 90 70 50
ARCTIC OCEAN
GREENLAND
DAVIS STRAIT
ALASKA
60°
50°
40°
30°
20°
10°
PACIFIC OCEAN
CANADA
HUDSON BAY
UNITED STATES
WASH
ORE
IDAHO
MONT
WYO
N DAK
S DAK
NEBR
IOWA
WIS
MICH
NY
ME
PA
OHIO
ILL
IND
CAL
NEV
UTAH
COLO
KANS
MO
KY
VA
W VA
ARIZ
N MEX
OKLA
ARK
TENN
N C
S C
MISS
ALA
GA
TEXAS
LA
FLA
MEXICO
GULF OF MEXICO
CUBA
ATLANTIC OCEAN
CARIBBEAN SEA
CENTRAL AMERICA
SOUTH AMERICA
● Deposits of chromic iron ore
500 0 500 1000 Miles
120°
110°
100°
90°
80°
70°

FIGURE 1.—Map of North America showing known deposits of chromic iron ore.

and markets the chrome ore used in making ferrochrome now selling at $400 a ton. The Geological Survey has suggested an increased and more stable price for chromite as a most effective means of increasing domestic production by encouraging and arousing the small producer to do his utmost.

---

[1] Rapp, F. A., The domestic production of chrome: Min. and Sci. Press, vol. 116, p. 113, Jan. 26, 1918. Lass, W. P., The ferrochrome situation: Eng. and Min. Jour., vol. 105, p. 244, Feb. 2, 1918

The price of 40 per cent chromite at the beginning of 1917 was $15 a ton, that is, 37½ cents a unit of chromic oxide, but at the end of the year the price had been raised to 70 cents a unit, or $28 a ton. The actual price reported to the Geological Survey ranged from $10 to $50 a ton and the average price of the ore sold during the year by producers was a little more than $24 a ton. Early in 1918 the price for 40 per cent ore reached 85 cents a unit ($34 a ton). The impending crisis resulting from lack of ships to import the ore needed for war purposes has impelled the principal consumer, the Electro-Metallurgical Co., of New York, to advance prices greatly in the hope of increasing domestic production. The statement of the company was published March 17, 1918, in the form of an appeal, as follows:

YOUR COUNTRY NEEDS CHROME ORE.

To Pacific coast prospectors and miners:

The California Chrome Co., which has operated in California and Oregon for the last two years, will contract for the balance of this year for chrome ore at a minimum price of $1.25 per unit for 38 per cent chromic oxide and upward.

Premiums will be paid for early delivery.

Advances will be made on good prospects for development work.

Settlements in full will be made on independent chemists' sampling and analysis on receipt of bills of lading and weight certificate.

This appeal ought to stimulate chrome mining on the Pacific coast and to arouse the prospector and miner to vigorous activity. Fixing the minimum price at $47.50 a ton for 38 per cent ore for the rest of the year, premiums for early delivery, advances for developing good prospects, and just terms of settlement will undoubtedly give a great impulse to increase of domestic production.

GRADE OF DOMESTIC ORE.

The block chrome ore sold on the Pacific coast in the summer of 1917 ranged in composition from 30 to 55 per cent chromic oxide and the average composition was 42 per cent.

Of the chromite mined and sold in the United States in 1917 22 per cent of the total quantity contained from 45 to 50 per cent of chromic oxide, 32 per cent contained from 41 to 45 per cent of chromic oxide, 36 per cent contained from 38 to 41 per cent of chromic oxide, and 10 per cent contained from 30 to 38 per cent of chromic oxide.

Of the ore marketed on the Pacific coast in 1917 nearly nine-tenths contained 38 per cent or more of chromic oxide and fell within the price of $1.25 a unit now offered. Important contracts for chromite ranging from 30 to 35 per cent chromic oxide have recently been signed, but the prices for that grade of ore have not yet greatly increased. It is hoped, however, that the large consumers of chrome ore for refractory purposes as well as for ferrochrome may further stabilize prices not only by adopting this scale of prices but by establishing a corresponding minimum price for ore below the grade of 38 per cent chromic oxide and thus contribute greatly to the increased production of low-grade ores and incidentally aid in promoting concentration.

CONCENTRATION OF CHROME ORE.

The importance of concentrating lower grades of chromite to fit them for higher uses and to save freight is fully recognized, and concentrating plants in considerable number are now either in operation, in course of construction, or in contemplation. In the gold region of the Pacific coast the miners are so familiar with crushing and concentrating auriferous quartz ores that they should readily take to the concentration of chromite. A concentrating plant was operated in San Luis Obispo County [1] more than 25 years ago, and two new concentrating mills will soon be at work in the same region. Ore was concentrated at the Collard mine during the summer of 1917, and the plant is now (March, 1918) improved and enlarged. An effective plant was built by the Placer Chrome Co. near Rattlesnake Bridge, in Eldorado County, 6 miles south of Newcastle. It has recently been enlarged and another mill is being built at Salmon Falls. In the same County (Eldorado) a short distance farther south, near Negro Hill, the Noble Electric Steel Co. is reported to have erected at its mine a concentrating plant with a daily capacity of 60 tons. Another concentrator is in course of construction at Folsom with a rated capacity of 50 tons daily. Machinery has been bought for a mill on the road between Auburn and Grass Valley, Placer County. In Tehama County, 7 miles from Lowry on the Klenisorge property, a 10-stamp mill with two tables has been recently placed in commission, and it is reported that another concentrating plant is to be erected in the same region. The Mineral Products Co. has a concentrator in Stanislaus County, and the Western Ores Co. reports one in course of construction in Butte County, 5½ miles east of Paradise. Another mill is reported to be running near Nevada City, in Placer County. Much has been said concerning a proposed mill in the Red Mountain region of Fresno County, and it is probable that before the end of the summer of 1918 there may be more than a dozen mills operating in California alone and a number of others elsewhere. North Carolina has a mill near Webster, in Jackson County, and there should be others at different points in the same county as well as in Buncombe and Yancey Counties, for North Carolina has a high grade of chrome ore. Concentrating mills are likely to follow farther north in Maryland and Pennsylvania, where chromite was extensively mined years ago.

All low-grade chrome ores can not be concentrated to advantage. This is especially true of low-grade ores in which the chromium has been replaced by aluminum and iron. Chrome ore rich in magnetite may under some conditions be successfully handled by a magnetic separator.

Concentrating plants have been a feature of the chrome industry in Canada ever since 1898 and two of the latest types of mills erected in that region are briefly described in this report for 1916.[2] It is believed that by a more extensive introduction of concentrating plants on the Pacific coast some low-grade ores not now available may be readily so beneficiated as greatly to aid in providing the needed supply for war purposes.

---

[1] Mineral Industry, p. 153, 1893.

[2] Diller, J. S., Chromite: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 35-37, 1917.

IMPORTS.

The most striking feature of the imports in 1917, shown in the accompanying table, is the great decrease in the total from 115,945 long tons in 1916 to 72,063 long tons in 1917. This decrease is due wholly to restricted shipping facilities on account of the war and affects particularly imports from South Africa and New Caledonia, which require long overseas transportation. On the other hand, the imports from Canada have greatly increased and those from Guatemala appear for the first time. Only 17 tons have come from Cuba, but recent developments indicate that Cuba and also Brazil will soon be large contributors to our needs of chromite.

Chromic iron ore imported into the United States, 1913-1917, in long tons.[a]

	1913	1914	1915	1916	1917
Cuba	....	....	....	34	17
Canada	....	533	10,087	12,220	19,012
England	....	58	2	5	5
Greece	4,600	8,155	4,305	7,900	....
Japan	79	....	....	....	....
French Oceania	21,850	30,860	28,031	[b] 30,950	10,300
Australia	....	....	....	[b] 2,986	....
British South Africa	....	....	22,800	[c] 23,000	4,750
Portuguese Africa	30,001	23,200	11,230	[c] 38,850	37,800
Turkey in Asia	8,650	11,880	....	....	....
Guatemala	....	....	....	....	179
	65,180	74,686	76,455	115,945	72,063

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, U. S. Dept. Commerce.

[b] E. J. Lavino & Co., importers, credit New Caledonia with all ore listed under French Oceania and Australia, amounting to 33,936 long tons.

[c] E. J. Lavino & Co., importers, credit Rhodesia with all ore listed under British South Africa and Portuguese Africa, amounting to 61,850 long tons.

Chromium compounds imported for consumption, 1915-1917.[a]

	1915			1916			1917		
	Quantity.	Value.	Price per unit.	Quantity.	Value.	Price per unit.	Quantity.	Value.	Price per unit.
Chromic iron ore.....long tons..	76,455	$780,061	$10.20	115,945	$1,548,402	$13.35	72,063	$1,110,659	15.41
Chromic acid..........pounds..	3,571	755	.211	......	....	......	......	....	......
Chromate and bichromate of potash..............pounds..	32,942	2,902	.088	459	75	.16	2,402	962	.40
Chrome or chromium and ferrochrome or ferro chromium ....long tons..	32	1,662	51.94	10	1,998	199.80	......	....	......
Chromate and bichromate of soda................pounds..	......	....	......	6,154	3,630	.59	22,025	4,075	.19

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, U. S. Dept. Commerce.

NEEDS FOR CONSUMPTION.

The measure of normal annual consumption of chromite for all the various uses before the war may best be expressed by the sum of domestic production and imports in 1913, about 65,000 long tons. On account of the greatly augmented demands of war conditions it has been estimated by the committee on mineral imports and exports of the Shipping and War Trade boards that the needs of the United States in 1918 will be equivalent to about 130,000 long tons of 50 per cent ore, of which 67,500 tons will be needed for ferrochrome, 40,000 tons for making bichromates and other chemicals for tanning, etc., and 22,500 tons for refractory purposes.

RECOMMENDATIONS.

The supplies available by imports, since those of Rhodesia and New Caledonia may be wholly or in large part cut off, are uncertain. The problem for the United States is to save shipping by increasing domestic production of chromite to its maximum capacity. The offer of the California Chrome Co. of a high price throughout the year for a relatively low-grade ore, with premiums for early delivery, reasonable terms of settlement, and advances to develop promising prospects if well backed up by the company should call forth from the prospectors and miners on the Pacific coast their best endeavors to supply the chromite needed for munitions to win the war.

The region attracting most attention, on account of its promising prospects, includes the adjacent portions of Del Norte County, Cal., and Curry County, Oreg. Facilities for mining and marketing this ore are urgently needed. A branch railroad is already in operation from Grants Pass to Waters Creek; if this road could be extended through the chromite region to Crescent City, it would have a great effect. Wagon roads should be provided in the national forests, and the little harbor of Crescent City should be improved to furnish adequate facilities for the needed transportation along the coast. It is believed that by hearty cooperation of all concerned the domestic production of chromite can be so increased as largely to release the shipping that would be required for imports.

Under the impulse of a great need and the favorable opportunity offered to arouse miners to strenuous efforts it is hoped and expected that the production of chrome ore in the United States in 1918 will be as much as 65,000 long tons of all grades, as noted in the following table:

Possible production of chromite and chromic oxide in 1918.

Grade of ore.	Quantity (long tons).	Content of chromic oxide (Cr_2O_3) (long tons).
38 per cent or more and concentrates	50,000	19,000+
30 to 37 per cent	10,000	3,500
25 to 29 per cent	5,000	1,350
	65,000	23,850

This output would be equivalent to 47,700 long tons of 50 per cent ore.

To this may be added 1,000 tons from Alaska, 25,000 tons of low-grade ore from Canada, with some from Newfoundland, as well as about 30,000 long tons from Cuba, Brazil, and Guatemala, and there would remain more than 40,000 long tons of various grades to be imported from New Caledonia and Greece.

LIST OF OWNERS AND OPERATORS OF DOMESTIC DEPOSITS OF CHROMITE.[1]

CALIFORNIA.

Adams, R. D., 1311 Humboldt Bank Building. San Francisco.
Agard, W. A. T., 268 Market Street, San Francisco.
Alexander, F. A., 633 Monadnock Building, San Francisco.
Altshuler, Samuel, 251 Montgomery Street, San Francisco.
American Exploration & Contracting Co., Grants Pass, Oreg.
Arata, P. A. H., Wade Building, San Luis Obispo.
Asbill, Frank, Alderpoint.
Atherton, F., Jamestown.
Aumaier, S., 1127 Monterey Street, San Luis Obispo.
Aurora Mining Co., The, Idria.
Auspach, William, Dunsmuir.
Austin, H. C., 56 Bacon Building, Oakland.
Avery & Son, Porterville.
Baldwin, W. T., Telephone Building, Oroville.
Barnes, G. W., Watts Valley.
Barton, G. S., Grants Pass, Oreg.
Bawman, B. C., Cazadero.
Beckwith, Robert, Jamestown.
Belknap & Co., Yreka.
Bell, L. C., St. James Hotel, San Luis Obispo.
Berlin, J. F., Newman.
Biggs, H. C., 2190 Sutter Street, San Francisco.
Bingham, Alonzo, Callahan.
Blockman Co., 224 Granger Block, San Diego.
Bones, W. H., Occidental.
Bonetti Bros., Latrobe.
Booker, W. E., Jamestown.
Brandon, R. G., Latrobe.
Brandon, Madison, Latrobe.
Brust, F. P., 3431 Harper Court, Oakland.
Bryant, Cullen, Latrobe.
Bunker, H. H., Michigan Bluff.
Burnett, F. L., Folsom.
Burnham, W. A., Copperopolis.
Burrows, I. A., Newville.
Butcher Co., L. H., 341 Montgomery Street, San Francisco.
California Chrome Co., J. B. Huffard, Prest., 1107 Kohl Building, San Francisco.
Carr, E. H., Mount Springs Chrome Co., R. F. D. 79, Ione.
Carson, Frank, Visalia.
Chaix, S., Latrobe.
Chase, H. B., Monticello.
Chastain, F. S., Gazelle.
Clark, B. F., Yankee Hill.
Clarke & McDonald, Livermore.
Clary, W. H., Canyon City, Oreg.
Coggins, Arthur L., Dunsmuir.
Collier, B. K., Yreka.
Conklin, Wells, Newville.
Copsey, A., Middletown.
Cory, W. C., Jamestown.
Courtwright, George, R. D. 79, Ione.
Crisle, John, Sanger.
Curran, W. E., Currans Ranch, Sanger.
Curtis, M. L. & Co., Seeley.
Dack, Walter, Hazel Creek.
Davis, J. C., Copperopolis.
Dean, P. S., Felix.
DeKruse, E., Iowa Hill.
Delano, M. A., Grants Pass, Oreg.
Demasters, S. D., Star Route, Sanger.
Dibble, C. H., 433 California Street, San Francisco.
Dodson, R. L., Latrobe.
Dooley, E. D., Plymouth.
Dolbear, S. H., 1411 Humboldt Bank Building, San Francisco.
Doolittle, E. B., Happy Camp.
Dougherty, C. F., Hazel Creek.
Dwyer, J. F., Yreka.
Egling & Williams, Chinese Camp.
Elzey, R. H., Santa Rosa.
Esper, J. E., Cool.
Evans, J. C., Clarksville.
Facey Bros. & Williams, Callahan.
Ferbrache, J. A., 63 Rosanna Street, Gilroy.
Ferzeck & Burns, Sonora.
Finster, G. L., Patterson.
Fledderman Bros., Yreka.
Fleischbein & Kinney, Folsom.
Ford, A. L., Auburn.
Forni, J. C., El Dorado.
Fritz, L. W., Pine Flat.
Fuqua, T. L., Lower Lake.
Garcia, C. M., San Simeon.
Garrison, E. A., Forest Hill.
Gastman, A. L., Arcata.
Geisendorfer, C. A., Weimar.
Geisenderfer, J. F., 2107 Fourth Avenue, Sacramento.
Gibbons, W. W., Watts Valley.
Gillis, C. A., Angels Camp.
Glenn, P. E., Fair Oaks.
Grant, J. M., Etna Mills.
Gravlin, C. W., Grants Pass, Oreg.
Green, W. C., Georgetown.
Griffin, Turner & Hopfield, Folsom.
Guthrie, Alexander, Harris.
Hampton, John, Patterson.
Harp Bros., Corcoran.
Hawkins, E. J., Crescent City.

---

[1] Anyone knowing the owner or operator of a domestic chrome deposit whose name does not appear in this list should send the name at once to the Director, U. S. Geological Survey, Washington, D. C.

Hearst, Mrs. Phoebe, Hearst Building, San Francisco.
Hill, S. W., Box 393, Red Bluff.
Hodges, J. R., Towle.
Hoeft, Miss Eleanor, Nevada City.
Hogan, Thomas, Nevada City.
Holbrook & McGuire, 1002 Crocker Building, San Francisco.
Hole, Theodore C., Watts Valley.
Hollister & Pierce, San Luis Obispo.
Hothersal, G. J., Nevada City.
Hoy, E. K., Hazel Creek.
Hughes-Kibbler Co., Santa Margarita.
Hyatt, R. E., 523 Rialto Building, San Francisco.
Hyde, George, Smith River.
Irish, C. F., Mgr., Consolidated Chrome Co., Georgetown.
Irwin Co., Yreka, Cal.
Jens, J. C., Belmont.
Jewett, C. H., Grass Valley.
Johnson, William, 4346 Townsend Avenue, Oakland.
Johnston, U. J., & Co., San Jose.
Kahl, Joseph, Jamestown.
Kelly, M. A., P. O. Box 45, Newcastle.
Khoeery, K. J., Takilma, Oreg.
Kilday, M., Los Gatos.
Kipp, J. W., Watts Valley.
Kleinsorge, W. E., P. O. Box 1126, Sacramento.
Krunich & Ninkovich, Porterville.
Lacey, Thomas, Academy.
Lambert, M., Magalia.
Latchens, E. C., Callahan.
Laton, A. H., Cazadero.
Lawley, C. A., Calistoga.
LeMay, Florian & Charles, Box 464, Yreka.
Levensaler-Speir Corporation, 681 Market Street, San Francisco.
Linder, R. E., Alta.
Logan, L. D., 235 Montgomery Street, San Francisco.
Luce, Alonzo, Willows.
Luchessa, A., San Luis Obispo.
Lyons, A. M., Fosteria.
M. and L. Chrome Co., F. S. Morgan, Mgr., Nevada City.
McAfee, David, Valley Springs.
McCormick, Robert, Sonora.
McFall, J. H., Copperopolis.
McMullen, J. R., P. O. Box 245, Dinuba.
McMurtry, William, Watts Valley.
MacBridge, George, Callahan.
Mackey, Peter, Jamestown.
Madeira, George, sr., 1550 Page Street, San Francisco.
Madrid, John, Angels Camp.
Maguire, William, Dutch Flat.
Maltby, C. S., 1311 Humboldt Bank Building, San Francisco.
Marks & Grant, Etna Mills.
Marris, E. A., Healdsburg.
Masterson, G. J., Callahan.
Matthews, G. C., Cloverdale.
Maxwell, Grover, Garden Valley.
Maxwell, J. A., Felix.
Maydell Co., Sheldon Building, San Francisco.
Mayfield, Solon, Cambria.
Mefford, Mrs. J. E., R. F. D. 79, Ione.
Mercer, Charles, Watts Valley.
Meyer, Fred, Weimer.
Miles, D. E., Hazel Creek.
Milsap, Oscar, Newville.
Mineral Products Co., 334 Rialto Building, San Francisco.
Moore, Vincent, Star Route, Sanger.
Morse, S. F. B., Crocker Building, San Francisco.
Morton & Boyer, Bayles.
Moscatelli, Robert, Washington.
Mott, G. L., San Luis Obispo.
Mullally, William, Monticello.
Mundrini, Michael, Latrobe.
Neely, F. M., 70 Fremont Street, San Francisco.
Neil, T. L., Pope Valley.
Neilsen & Donnelly, Folsom.
Netherton, W. P., Mgr., Placer Chrome Co., Santa Cruz.
Nettleton & Swanton, Newcastle.
Nichelini, A., St. Helena.
Niles, Walter, Washington.
Noble Electric Steel Co., 995 Market Street, San Francisco.
Noise Co., San Luis Obispo.
Norcross, D. C., 430 California Street, San Francisco.
Null, J. E., Chinese Camp.
O'Brien, James, Plymouth.
Ogden, B. A., Knights Ferry.
Ogle, E. C., Volcanoville (Georgetown).
Osborn, Samuel, Altaville.
Page, J. E., Willits.
Palmer, F. S., 244 California Street, San Francisco.
Patterson, Schroeder & Woldenburg, Canyon City.
Payne, L. R., Academy.
Pereira, W. M., Chinese Camp.
Peri, Frank, Copperopolis.
Pfeifer, William, Latrobe.
Philpot, C. H., Mill Valley.
Pierce, W. W., Morro.
Pierce & Hollister, San Luis Obispo.
Pilliken, G. J., Folsom.
Plattner, J. H., Livermore.
Quigg, C. M., Jamestown.
Rice, Charles, Watts Valley.
Riffe, J. S., Sanger (Star Route).
Riffe, Sloane, Watts Valley.
Roeper, J. C., Independence.
Rohrer, G. C., Pulga.
Root, Frank, 1152 Sacramento Street, San Francisco.
Rose, Frank, Sanger.
Ross, William, & Co., Takilma, Oreg.
Rowen, R. J., Grants Pass, Oreg.
Rushing, J. H., Jamestown.
Saint, R. E., Watts Valley.
Sanger Mining Co., Sanger.
Sawyer Tanning Co., Napa.

Schoettgin, F. J., Columbia.
Schroeder, H. C., Nevada City.
Schuler & Park, Happy Camp.
Scoble, John, Watts Valley.
Scott, George, Towle.
See, Jacob, Santa Margarita.
Sell, J. A., Sonora.
Shafer & Atherton, Jamestown.
Shanks, D. W., 1106 Merchants National Bank Building, San Francisco.
Shelden, G. E., 302 Key System Building, Oakland.
Siebert, J. B., Star Route, Sanger.
Sims, Henry, Chinese Camp.
Simmons, D. B., Yankee Hill.
Snow, C. S., Academy.
Sowers, H. F., Smith River.
Stokes, L. R., Yankee Hill.
Stratton, Dr. D. E., Chinese Camp.
Strickland, C. E., Callahan.
Stuck, W. R., care of Patterson & Western Ry., Patterson.
Sullivan, D. J., Dutch Flat.
Swayne Lumber Co., R. N. Swayne, 430 Sansome Street, San Francisco.
Sweet, John, Wolf.
Tedoc Co., W. A. T. Agard, Mgr., 268 Market Street, San Francisco.
Terrill, William, Trimmer.
Terry, C. W., Sonora.
Thompson, H., Wolf.
Trinidad Mining Co., 341 Montgomery Street, San Francisco.
Tucker, Henry, Calistoga.
Turner, R. C., Grass Valley.
Turner, R. L., Colfax.
Uldall, N. J., Red Bluff.
Union Chrome Co., 180 Sutter Street, San Francisco.
Vance, Homer, Star Route, Sanger.
Vanderford Bros., Elk Creek.
Van Fleet, J. R., Supt., California Chrome Co., Kohl Building, San Francisco.
Van Winkle, Walton, 149 California Street, San Francisco.
Vaughn, D. A., Estate, Porterville.
Visalia Land & Investment Co., Frank Carson, Visalia.
Wait, A. L., Drytown.
Wakeham, A. L., Magalia.
Wallace, R. W., Pope Valley.
Walsh, C. H., East Auburn.
Walter, C., San Luis Obispo.
Ward, George, Fosteria.
Wear, E. T., Paso Robles.
Welker, A. J., Callahan.
Wells, H. Bulkeley, Holbrook Building, San Francisco.
Wells, John, Yankee Hill
Wentworth, G. E., Placerville.
West, W. M., Towle
Westover, William, Hazel Creek.
Whitney, John, Yreka.
Wiley, D. E., Folsom City.
Williams, William, Calistoga.
Williamson, O. S., Iowa Hill.
Wood, Charles, Placerville.
Wood, G. E., Star Route, Sanger
Zaar, Frank, Smith River.
Zerfing Bros., Cayucos.
Zenith Chrome Mining Co., 2101 East Twelfth Street, Oakland.

MARYLAND.

Maryland Chrome Corp., Canton National Bank Building, Baltimore.

MONTANA.

Brophy, J. F., Washoe.
Grupp, A. F. E., Twin Bridges.
Purdy, S. C., Great Falls.

NORTH CAROLINA.

Carolina Chrome Co., Webster, N. C.
Nickel Co., J. J. Hooker, Mgr., Sylva.
Ray Heirs, G. D., J. B. Roy, Burnsville.
Wilson, J. H., Sylva.

OREGON.

Adams, E. F., Oregon Nickel Mining Co., Oakland, Cal.
Barton, G. S., Box 646, Grants Pass.
Brown, C. W., Canyon City.
Brown, W. Q., Riddle.
Butler, D. M., Canyon City.
California Chrome Co., Kohl Building, San Francisco, Cal.
Cane, Frank, Riddle.
Collard, G. W., Kerby.
Costelloe & Keaton, Harbor.
Cunningham, A. A., 434 Harrison Street, Portland.
Curl, R. M., Canyon City.
Delano, M. A., Grants Pass.
Dunn, A. W., John Day.
Davis & Patrick, Ashland.
Fehely, R. C., Grants Pass, Kerby.
Finch & Johnson, Box 106, Kerby.
Geitsfield Bros., Canyon City.
George, L. L., Canyon City.
Gilmore, W. E., Kerby.
Gorman, Thomas, Rye Valley.
Grant Chrome Co., Prairie City.
Glasscock, Roy, Mount Vernon.
Hamer, Shelby & Delore, Dayville.
Hanenkrat, A. E., Prairie City.
Hazeltine, I. B., Canyon City.
Kight, F. M., Prairie City.
Kromite Mining Co., T. F. Adams, Payette, Idaho.
Lyon, Frank, Unity.
Lyon, H. T., Canyon City.
McCorkle & Andrus, Canyon City.
MacIntyre, L. H., Canyon City.

Mascall, O. R., Dayville.
Page, J. E., Willits.
Patterson, Otis, Canyon City.
Patterson, Schroeder & Woldenberg, Canyon City.
Peet, F. W., Prairie City.
Powers, D. W., Canyon City.
Reddy, T. F., Grants Pass.
Reese, R. C., Prarie City.
Rowen, R. J., Selma.
Smith, F. F., Galice.
Smith, W. H., Canyon City.
Stockwell, M. F., Canyon City.
Stone & Hawkins, Mount Vernon.
Uldall, Martin, Grants Pass.
Vancil, W. N., Seneca.
Ward, G. F., Canyon City.
Williams, Dr. J. J., Pacific Grove, Cal.
Woldenberg, L., Canyon City.
Zenith Chrome Mining Co., 2101 East Twelfth Street, Oakland, Cal.

PENNSYLVANIA.

Squier, Lee W., secretary Chrome Mining Co., Finance Building, Philadelphia.

WASHINGTON.

Joiner, George, Anacortes.
Smith, Mrs. G. B., Seattle.

CADMIUM.

By C. E. Siebenthal.

INTRODUCTION.

A brief account of the production, resources, metallurgy, and uses of cadmium was given as a chapter in Mineral Resources, 1908. A more detailed report is in preparation and will be published as a bulletin of the United States Geological Survey. The present report gives the production of cadmium in the United States since the beginning of the industry in 1907, the chief sources of the metal in the United States, the principal uses, the imports for 1903 and later years, the range of fluctuation in price in 1917, and the yearly average selling price since 1907.

PRODUCTION.

Cadmium was first produced in the United States by the Grasselli Chemical Co. in 1907. One by one other companies began the recovery of cadmium until there are now six producing companies, as follows: American Smelting & Refining Co.; Grasselli Chemical Co.; Krebs Pigment & Chemical Co.; Mammoth Copper Mining Co.; Midland Chemical Co.; and United States Smelting, Refining & Mining Co. As cadmium residue resulting from the production of electrolytic spelter is accumulating at several plants there will doubtless be other producers before long.

Cadmium is produced in the United States in two forms—metallic cadmium and the pigment, cadmium sulphide. The domestic production of metallic cadmium in 1907 was nearly sufficient to supply the home demand, a fact shown by the small imports for that year, but in 1908 the quantity of cadmium imported was almost doubled, and in 1909–1912 the imports were back at the figures that prevailed before cadmium had been produced in the United States. Since 1912, however, the domestic production has made great strides, and as a result the imports of cadmium are again small. As the imports came largely from Germany they have been practically stopped for the last four years.

The following table, compiled from reports by each producer of cadmium in the United States and from official reports of the German Government, shows that the production of cadmium in the United States since 1910 has made rapid gains on that of Germany. Taken together the production of these two countries constitutes practically the whole cadmium production of the world.

Metallic cadmium and cadmium sulphide produced in the United States and Germany, 1907–1917.

Year.	United States.						Germany.		
	Metallic cadmium.			Cadmium sulphide.			Metallic cadmium.		
	Quantity (pounds).	Value.	Average price per pound.	Quantity (pounds).	Value.	Average price per pound.	Quantity (pounds).	Value.	Average price per pound.
1907	14,000	$14,350	$1.025	(a)	....	....	72,639	$60,757	$0.84
1908	8,000	6,000	.75	(a)	....	....	72,741	48,590	.67
1909	5,300	2,783	.525	(a)	....	....	81,982	46,777	.57
1910	4,700	2,585	.55	(a)	....	....	90,516	39,309	.43
1911	26,152	17,566	.67	2,392	$1,674	$0.70	93,861	53,372	.57
1912	52,508	39,875	.76	8,998	6,400	.71	94,262	63,507	.67
1913	54,198	41,838	.77	17,302	12,136	.70	81,993	63,641	.78
1914	[b] 91,409	81,205	.89	22,723	20,241	.88	(c)	....	....
1915	91,415	108,443	1.19	10,624	12,057	1.13	(c)	....	....
1916	135,212	210,931	1.56	22,176	27,942	1.26	(c)	....	....
1917	207,408	305,097	1.47	50,169	70,939	1.41	(c)	....	....
	690,302	830,673	....	134,384	151,389	....	....	....	....

[a] No production.
[b] Exclusive of 4,225 pounds of cadmium in residues sold for export.
[c] No figures showing the cadmium production in Germany later than 1913 are available.

SOURCES.

Before cadmium was produced in the United States in large quantity its greatest output came from the zinc-producing regions of Silesia, where it is recovered as a by-product in the distillation of zinc. No cadmium is recovered in the United States in the distillation of zinc ores, but most of the output is derived from baghouse dusts at lead smelters that treat lead ores containing more or less zinc. In England and in the United States some cadmium is recovered in purifying the solution of zinc sulphate used in making lithopone. Another source of cadmium is the residue left in making zinc chloride from low-grade zinc ores and from zinc ashes and drosses. Still other sources which may become important are the anode muds resulting from the electrolytic refining of spelter and the muds that are precipitated in purifying the electrolyte preparatory to depositing zinc in the reduction of zinc ores by leaching and electrolytic deposition. In view of the increasing number of electrolytic zinc plants this source offers great promise for a large output of cadmium. The presence of more than 0.05 per cent of cadmium in spelter prevents its being classed as grade A in the Navy specifications of June 1, 1917, so that electrolytic plants now remove cadmium from the electrolyte usually by precipitation with zinc dust.

The fumes driven off in making brass are richer in cadmium than the spelter used, for the more volatile cadmium is driven off in greater proportion than the zinc and is thus concentrated in the fumes. Zinc-oxide flue dusts recovered from brass works show 2 to 3 per cent of cadmium. The use of these zinc dusts in making lithopone would permit also the recovery of the cadmium, which would be further concentrated in the vats. It has been estimated that 400 pounds of cadmium is lost daily in fumes from the brass foundries at Waterbury, Conn.[1]

---

[1] Parsons, C. L., Jour. Ind. and Eng. Chemistry, vol. 4, p. 186, 1912.

USES.

Cadmium is used in metallic form chiefly in alloys, and its various salts are used in the arts, in medicine, and in electroplating.

ALLOYS.

Cadmium lowers the melting point of alloys in which it is used and is therefore employed in making easily fusible alloys and soft solders, such as those used in the fusible plugs of automatic sprinkler systems. It is also used in making fusible safety plugs for boilers and electric fuses. Cadmium cliché metal is superior to the corresponding bismuth cliché metal for making stereotype plates.

Since tin has become scarce cadmium has been increasingly used as a substitute for tin in solders, such as the "half and half" lead-tin solder. Though cadmium is worth half as much again as tin it can be profitably substituted for tin in some solders, for less cadmium and more lead is used; moreover the tin available is required for uses for which there is no substitute. The supply of cadmium can easily be increased to meet any reasonable demand. It is highly desirable that some research laboratory undertake an intensive study of cadmium, particularly of cadmium alloys, to determine fully the availability of cadmium as a substitute for tin and to discover new uses for it.

Cadmium and cadmium compounds have been declared contraband of war by nearly all the belligerents, hence they must have military uses, but naturally there is not much authoritative information about such uses. A fraction of 1 per cent of cadmium is used in copper telegraph and telephone wires and cables in France and Italy. It is reported that such cables heavily charged with electricity are used in the wire entanglements before the trenches at the front. Cadmium is reported to be used in smoke bombs for signaling.

It is reported that relatively large quantities of cadmium were exported to Germany before the war for use in making small-arms ammunition. A cadmium band on the hard-jacketed cartridge ball is said to take the rifling with little wear on the barrel and thus prolong the life of the gun.

SALTS OF CADMIUM.

The sulphide of cadmium is the brilliant pigment cadmium-yellow or jaune brillant. Properly prepared it is one of the most permanent pigments known, and it is unaffected by hydrogen sulphide gas from coal smoke, whereas the common yellow pigments (lead chromes) are blackened in a smoky atmosphere. Cadmium-yellow is therefore employed as a protective coating over chrome-yellow in painting street cars and the passenger coaches on some railway lines.

Sulphide of cadmium is extensively used to give color and luster to glass and porcelain.

Other cadmium salts are used in dentistry, dyeing, photography, and electroplating.

IMPORTS.

Cadmium is imported into the United States as metallic stick cadmium and as the pigment, cadmium sulphide. The former is free of duty; the latter is dutiable at 30 per cent ad valorem. The value of the imports for consumption of metallic cadmium for 1903 to 1917, inclusive, is given in the table below, which is taken from the records of the Bureau of Foreign and Domestic Commerce. The quantities are not there recorded previous to July, 1909, and for the period preceding that time they have been computed by dividing the values of the imports by the average price of cadmium for the corresponding year in Germany, from which country the cadmium was imported. The quantity and value of cadmium imported as a pigment are not recorded separately by the Bureau of Foreign and Domestic Commerce.

Cadmium imported and entered for consumption in the United States, 1903–1917.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1903	[illegible]679	$4,565	1910	4,060	$2,295
1904	[a]7,655	4,524	1911	5,367	3,870
1905	[a]8,138	5,298	1912	5,250	3,764
1906	[a]13,808	10,522	1913	1,656	1,232
1907	[a]1,953	1,633	1914	441	368
1908	[a]3,567	2,390	1915	269	284
1909 first half	[a]6,659	4,559	1916	....	....
1909 second half	2,203		1917	....	....

[a] Prior to July, 1909, the quantities are computed as noted above.

EXPORTS.

Complete statistics of the exports of cadmium are not available, but it is known that domestic cadmium has been largely exported during the war. According to the Bureau of Foreign and Domestic Commerce the following quantities of cadmium were exported through the port of New York in the last quarter of 1916: In October, 33,244 pounds, valued at $55,259; in November, 4,900 pounds, valued at $5,100; and in December, 1,044 pounds, valued at $1,530. Of the exports in October, 23,210 pounds went to France, 9,984 pounds to Italy, and 50 pounds to Dutch Guiana.

Unrefined cadmium in cadmium residues has also been exported, as noted above.

PRICES AND VALUE.

The price of stick cadmium throughout the first half of 1917 was listed in retail lots as nominal at $1.50 a pound. During the last half of the year the quotations remained practically stationary at $1.40 to $1.75 a pound. The average price for 1917 as calculated from sales was $1.47 a pound, as compared with an average of $1.56 a pound in 1916. The price in London during the first four months of 1917 was 7s. 7½d. ($1.75) a pound; during the next five months it was 8s. 1½d. ($1.90) a pound, and for the remainder of the year it was from 7s. 3d. to 7s. 7½d. ($1.70 to $1.75) a pound.

The average selling price of cadmium sulphide in the United States in 1917 was $1.41 a pound, as compared with $1.26 a pound in 1916.

The value of the output of cadmium in the United States in 1917, calculated at the average selling price, was $305,097, as compared with $210,931 in 1916, and the value of the cadmium sulphide produced was $70,939, as against $27,942 in 1916.

The total value of the output of metallic cadmium in the United States since the beginning of production in 1907 is $830,673 and of cadmium sulphide $151,389, both together equal to nearly a million dollars.

BIBLIOGRAPHY.

The following list of books and articles on cadmium includes only the longer and more important papers which have appeared in recent years:

Blassett, Emmanuel, jr., The electrodeposition of cadmium: Metal Industry, vol. 9, pp. 509–510, 1911.

Ingalls, W. R., The metallurgy of zinc and cadmium, p. 701, 1906.

——— Memorandum respecting the quality of spelter suitable for the manufacture of cartridge brass and other high-grade brass; with an appendix containing reprints of various articles from the Engineering and Mining Journal and discussion of papers read at the American Institute of Metals. Pamphlet, privately printed, p. 44, 1917.

Jensch, Edmund, Das Cadmium, sein Vokommen, seine Darstellung und Verwendung: Samml. chem. u. chem.-tech. Vorträge, vol. 3, pp. 201–232, 1908.

Juretzka, Franz, Metallurgy of cadmium—raw materials, technique and economics: Met. and chem. Eng., vol. 16, pp. 146–148, 1917; translated by O. C. Ralston from Metall und Erz, vol. 12, p. 235, 1915.

Liebig, Max, Zink und Cadmium, p. 598, 1913.

Mather, F. C., and Marble, H. M., The electrodeposition of cadmium: Am. Electrochem. Soc. Trans., vol. 25, pp. 297–333, 1914.

Schnabel, Carl, Cadmium: Handbook of metallurgy, translated by Henry Louis, vol. 2, pp. 317–328, 1907.

Siebenthal, C. E., Cadmium: U. S. Geol. Survey Mineral Resources, 1908, pt. 2, pp. 793–803, 1909.

Speier, Paul, Cadmium: Min. Jour. [London], vol. 82, p. 573, Nov. 9, 1907.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN THE EASTERN STATES.

(MINES REPORT.)

By JAMES M. HILL.

MINE PRODUCTION.

The total value of the output of gold, silver, copper, lead, and zinc in the Eastern States was $42,073,581 in 1917, a decrease of about 7 per cent from the production in 1916. The total value is distributed among the various metals as follows: Gold, $29,227; silver, $87,714; copper, $4,930,672; lead, $591,598; zinc, $36,434,370.

As will be seen from the following table, the decrease in value is due to the decreased output of gold and to the reduction of the average value for zinc and is not an index of the quantity of metals produced in the Eastern States, which increased considerably.

Mine production of gold, silver, copper, lead, and zinc in the Appalachian States, 1916–17.

Year.	Ore sold or treated.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.[a]
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	2,241,113	$64,370	100,323	17,104,303	1,582,034	287,889,687	$45,260,290
1917	2,702,266	29,227	106,450	18,061,068	6,879,053	310,336,805	42,073,581
Increase or decrease	+461,153	−35,143	+6,127	+956,765	+5,297,019	+22,447,118	−3,186,709

[a] The value of the production of zinc in 1916 and 1917 is not all calculated at the average zinc price used by the Survey.

GOLD.

The mine production of gold in the Eastern States in 1917 was only 1,413.86 fine ounces, having a total value of $29,227, as compared with 3,113.90 fine ounces valued at $64,370 in 1916. Of this output the placers yielded 336.41 ounces, the siliceous gold ores 416.17 ounces, and copper ores 661.28 ounces. As was to be expected, very few gold mines were worked during 1917, owing to the increased cost of operation and the fixed price of the product. On the other hand, the copper mines increased their operations and made greater recoveries of both gold and silver.

SILVER.

In 1917 the mine production of silver in the Eastern States was 106,450 fine ounces, valued at $87,714, an increase of about 6,100 ounces over the output in 1916. The largest production was from copper ores and the smallest from placer mines, as is shown by the second table below. There was a considerable increase in the silver recovered from copper ores mined in Tennessee and Virginia, and some silver was derived from lead-zinc ores mined in the latter State.

Mine production of gold and silver in the Eastern States in 1917, by States.

State.	Gold.		Silver.		Increase or decrease in value compared with 1916.	
	Quantity.	Value.	Quantity.	Value.	Gold.	Silver.
	Fine ounces.		*Fine ounces.*			
Alabama and Georgia	442.68	$9,151	57	$46	-$22,038	- $38
Maryland, New Hampshire, and Vermont	6.62	137	1,709	1,409	+ 137	- 1,237
North Carolina	589.55	12,187	1,110	915	- 14,050	+ 479
South Carolina	52.39	1,083	3	2	+ 763	- 16
Tennessee	257.65	5,326	99,053	81,619	- 413	+19,306
Virginia	64.97	1,343	4,518	3,723	+ 458	+ 3,208
	1,413.86	29,227	106,450	87,714		
Increase or decrease	1,700.04	-35,143	+6,127	+21,702	- 35,143	+21,702

Mine production of gold and silver in the Eastern States in 1917, by sources, in fine ounces.

State.	Gold.			Silver.		
	Placers.	Dry or siliceous ores.	Copper ores.	Placers.	Dry or siliceous ores.	Copper ores.
Alabama and Georgia	135.99	306.69		9	48	
Maryland, New Hampshire, and Vermont			6.62			1,709
North Carolina	192.48	65.03	[a] 332.04	34	97	[a] 979
South Carolina	7.94	44.45			3	
Tennessee			257.65			99,053
Virginia			[a] 64.97			[a] 4,518
Total, 1917	336.41	416.17	661.28	43	148	106,259
Total, 1916	803.81	1,984.91	325.18	148	411	[a] 99,764

[a] Includes some gold and silver from lead ore.

COPPER.

The mine production of copper in the Eastern States in 1917 was 18,061,068 pounds, valued at $4,930,672, an increase in quantity over 1916 of 956,765 pounds and in value of $723,013. This copper was largely derived from Tennessee ores, but some came from the copper-bearing magnetite ores of Pennsylvania and from copper ores mined in Georgia, Maine, Maryland, North Carolina, Vermont, and Virginia. The total quantity of ore and tailings treated to produce this copper was 923,251 tons, showing an average yield of copper of approximately 0.9 per cent, or about 18 pounds a ton.

LEAD.

The mine production of lead in the Eastern States in 1917 was 6,879,053 pounds, valued at $591,598, an increase of nearly 335 per cent in quantity and of about 440 per cent in value. Tennesssee mines produced 5,061,937 pounds, but more than 1,700,000 pounds were produced in Virginia, and there was also a considerable production from New Hampshire and a small quantity from North Carolina.

ZINC.

The production of zinc in the Eastern States in 1917 was 310,336,805 pounds, valued at $36,434,370, an increase in quantity of 22,447,118 pounds over the production in 1916. It will be noted that this value is more than it would be if the zinc content of the ore were calculated as spelter at 10.2 cents a pound, which was the average sales price of all grades of spelter in 1917. The difference is because of the fact that the zinc ore mined in New Jersey is not all used for the manufacture of spelter and its value is therefore calculated on a basis which gives a combined value of the zinc oxide and of the high-grade spelter produced.

New Jersey produced more zinc than all the remaining Eastern States, and Tennessee was second, with an output of nearly 57,000,000 pounds. New York and Virginia were next in rank with approximately 10,300,000 and 3,400,000 pounds, respectively. There was also a small output from New Hampshire.

REVIEW BY STATES.

ALABAMA.

Only one mine in Alabama, the Gold Log, near Talladega, marketed metals during 1917. Apparently no one worked at the placer mines near Arbacoochee, but some development was done on the Jemison property in Chilton County and at the Pinetuckey mine in Randolph County.

GEORGIA.

In 1917 mines in Georgia produced 333.26 ounces of gold, valued at $6,889, 46 ounces of silver, valued at $37, and 930,691 pounds of copper, a decrease of $15,650 in the value of gold and of 28 ounces in the quantity of silver from the production in 1916. The production of copper in 1917 was due to the reopening of some of the mines in the Ducktown district, which lie in Fannin County, Ga.

Of the output in 1917, placer mining furnished 135.99 ounces of gold and 9 ounces of silver, the remainder coming from deep mines. The deep gold mines in operation in the State treated 44,610 tons of siliceous ore, from which 197.27 ounces of gold and 37 ounces of silver were recovered.

Mine production of gold, silver, and copper in Georgia, 1916–17.

Year.	Number of mines.		Ore sold or treated.	Gold.[a]	Silver.[a]	Copper.	Total value.
	Placer.	Deep.					
			Short tons.		*Fine ozs.*	*Pounds.*	
1916	20	6	46,944	$22,539	74	803,699	$220,298
1917	13	6	44,610	6,889	46	930,691	261,005
Increase or decrease in 1917	−7	....	−2,334	−15,650	−28	+126,992	+40,707

[a] Includes placer gold and silver.

Placer mines numbering 13 were operated in Dawson, Cherokee, Haralson, Lumpkin, Rabun, White, and Wilkes counties. Five placers in Lumpkin County produced 55.36 ounces of gold. The White County placers, including the Loud mine, made nearly as much gold and considerably more silver than those of Lumpkin County.

Five deep gold mines reported production in 1917. The Pine Mountain mine in Douglas County, near Villa Rica, was operated by T. H. Aldrich, jr., part of the year but is reported closed down at present. In Lumpkin County gold and silver were produced from deep mines on the Crown Mountain and Lockhart properties. Prospecting was continued at the Royal mine in Haralson County.

The Columbia mine in McDuffie County was operated by the American Venture & Mines Corporation.

It is reported that the Bell Star mine near Woodstock, Cherokee County, is being developed.

The Georgia Copper Co. is opening a mine near Lincolnton, Lincoln County, and expects to begin production about the middle of 1918.

MAINE.

The American Smelting & Refining Co. have reopened the old Douglas mine, at Blue Hill, Me., and treated the siliceous chalcopyrite ore by flotation, making a small production of copper.

MARYLAND.

The New London mine, near Frederick, Md., was operated during 1917 and produced silver-bearing copper ore, and the Liberty Bell mine, near Union Bridge, produced some copper and silver from ore and tailings. Prospect work near Great Falls has been stopped for the present, but it is reported that the project has not been abandoned.

NEW HAMPSHIRE.

The Silver Lake mines, in Carroll County, N. H., were operated in 1917 and produced 3,000 tons of lead and zinc ore, from which 96,000 pounds of lead and 90,100 pounds of zinc were obtained. None of the other metal mines in the State reported operations during that year.

NEW JERSEY.

The production of New Jersey is, as usual, confined to the output of the Mine Hill and Stirling mines at Franklin Furnace, Sussex County. There were 720,561 tons of crude ore produced at those mines in 1917, which yielded a total of 239,462,000 pounds of zinc calculated as zinc in oxide and spelter. It should be understood that only part of the zinc ore mined at Franklin Furnace is used directly for the manufacture of spelter. The greater part of this zinc is normally converted into oxide at works located in Pennsylvania.

NEW YORK.

The Northern Ore Co., operating the Brown and White mines, near Edwards, St. Lawrence County, N. Y., was the only producer in the State in 1917. It treated 47,961 tons of zinc-bearing ore, which yielded about 10,384,000 pounds of zinc.

The Old Ellenville mine, Ulster County, is being unwatered by the Empire State Zinc & Copper Co.

NORTH CAROLINA.

The gold, silver, copper, and lead produced in North Carolina in 1917 had a value of $47,447, distributed as follows: Gold, 589.55 ounces, valued at $12,187; silver, 1,110 ounces, valued at $915; copper, 124,991 pounds, valued at $34,123; and lead, 2,583 pounds, valued at $222. Of the gold about 67 per cent was obtained from siliceous gold ores and the remainder from placer deposits. Of the silver, about 97 per cent came from siliceous gold ores and the rest from placers. The gold ores treated yielded an average of $5 a ton in precious metals. The copper was derived from ore and tailings from Ashe and Union counties, which yielded approximately 100 pounds of copper a ton.

As will be seen from the following table, the production of gold fell below the low of 1916, as was to be expected, but the production of silver and base metals increased materially. The most notable feature of the operations in 1917 is the production of lead, which came largely from the dumps of the Silver Hill mine in Davidson County.

Mine production of gold, silver, copper, and lead in North Carolina, 1916–17.

Year.	Number of mines.		Ore sold or treated	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
	Placer.	Deep.						
			Short tons.		*Fine ounces.*	*Pounds.*	*Pounds*	
1916	20	6	3,918	$26,237	663	9,800	....	$29,084
1917	14	7	2,087	12,187	1,110	124,991	2,583	47,447
Increase or decrease, 1917	−6	+1	−1,831	−14,050	+447	+115,191	+2,583	+18,363

[a] Includes placer

There were 14 operators of placer mines in North Carolina in 1917, the largest being W. E. Sudlow, at the Biggerstaff and Melton mines, Golden, Rutherford County. Placer gold was won in Burke, Cabarrus, Caldwell, McDowell, Montgomery, and Stanley counties, but the number of operators in each county and their individual production was relatively small. It is possible that some of the gold reported as from placer mines actually was obtained by reworking old dumps and cleaning up abandoned mills.

Seven deep mines were in operation for a part or the whole of the year in Ashe, Cabarrus, Davidson, Montgomery, Randolph, and Union counties. The largest production from deep mines was made by the Ore Knob mine, in Davidson County, but it is reported that work has been stopped.

It is said that new interests are investigating the Pioneer Mill mine in Cabarrus County.

The slag and tailing dumps at the Silver Hill mine, in Davidson County, were reworked, though only small shipments were made owing to car shortage.

The Copper King mine, in Person County, and the Gardner Hill mine, in Guilford County, together with the Seaboard mine, in Halifax County, Va., have been taken over by Baltimore interests and a 50-ton smelter to handle the ores from all of these properties is being built at Virgilina.

Apparently the Rich Cog, Steel, and Reynolds mines are the only properties under development in Montgomery County.

A little gold was won in Rowan and Stanley counties, most of which apparently came from reworking dumps and a little from sluice operations. It is stated, however, that the dumps of the Union mine will be milled in 1918.

The Clinchfield Gold Mining Co. is operating a mine near Logan, Rutherford County. Most of the gold produced in the county is won by placer mining, there being a number of small operators, particularly in Golden Valley.

At the Howie mine, Union County, the new 50-ton cyanide mill was completed and a considerable production of gold and silver made at both the mill and from the ore shipped to the smelter.

PENNSYLVANIA.

The Cornwall iron mines, in Lebanon County, Pa., now operated by the Bethlehem Steel Co., produced a copper concentrate from pyritiferous magnetite ore.

SOUTH CAROLINA.

In 1917 mines in South Carolina produced 52.39 ounces of gold and 3 ounces of silver, having a total value of $1,085, the largest part of which came from deep mines near McCormick, McCormick County, though a small quantity of placer gold was obtained during prospect work near Tamassee, Oconee County.

TENNESSEE.

The mine production of precious metals in Tennessee in 1917 was 257.65 ounces of gold and 99,053 ounces of silver, having a combined value of $86,945, all of which was derived from the copper ores of Polk County. This is a reduction from the output of gold of 1916, but an increase of 4,352 ounces of silver. No gold or silver ores were treated in the State, nor were the placer deposits of Monroe County operated. There were 589,004 tons of copper ore treated in Polk County, from which 16,033,749 pounds of copper were produced. Tennessee produced about 5,062,000 pounds of lead, which was obtained from mines in Washington and Union counties. The production of zinc in 1917 was 56,995,107 pounds, an increase of 4,139,627 pounds over the output in 1916. Lead and zinc ores were also produced at mines in Claiborne, Jefferson, Knox, Washington, and Union counties. The average content of zinc ore from Tennessee smelted direct in 1917 was 37 per cent, and the milling ore averaged 3 per cent zinc. Lead was produced from lead-zinc ore carrying 3.5 per cent lead.

Mine production of gold, silver, copper, lead, and zinc in Tennessee, 1916–17.

Year.	Number of mines.		Ore sold or treated.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Copper.	Lead and zinc.							
			Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	2	6	1,184,821	$5,739	94,701	14,679,794	32,960	52,855,480	$10,764,189
1917	2	5	1,533,983	5,326	99,053	16,033,749	5,061,937	56,995,107	10,712,985
Increase or decrease, 1917	......	−1	+349,162	−413	+4,352	+1,353,955	+5,028,977	+4,139,627	−51,204

VERMONT.

The Eureka mine, Orange County, Vt., was operated by the Pike Hills Mines Co., which has installed a 100-ton flotation mill.

It is reported that the Ely Copperfield Associates will reopen the old Ely mine at Copperfield, as well as the Orange, Green Mountain, and Walker properties.

VIRGINIA.

The mine production of gold, silver, copper, lead, and zinc in Virginia in 1917 was valued at $510,212, distributed as follows: Gold, 64.97 ounces, valued at $1,343; silver, 4,518 ounces, valued at $3,723; copper, 36,630 pounds, valued at $10,000; lead 1,718,533 pounds, valued at $147,794; zinc, 3,405,420 pounds, valued at $347,352.

Copper ores were mined in the Virgilina district, lead-bearing zinc ores in Spotsylvania and Louisia counties and also in Wythe County, and zinc ores in Russell county. No gold mines were operated in the State during 1917, the gold and silver reported being contained in lead, zinc, and copper ores.

Mine production of gold, silver, copper, lead, and zinc in Virginia, 1916–17.

	Number of mines.	Ore sold or treated.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	11	39,262	$885	783	553,800	1,455,844	4,551,237	$847,955
1917	5	35,551	1,343	4,518	36,630	1,718,533	3,405,420	510,212
Increase or decrease, 1917	−6	−3,711	+458	+3,735	−517,170	+262,689	−1,145,817	−337,743

The Seaboard mine, Halifax County, together with several other properties in the Virgilina district, has been taken over by Baltimore interests. A 50-ton smelter is under construction near Virgilina to handle the ores from the consolidated mines.

The Valcooper (Alla Cooper) and Valzinco (Holladay) mines in Louisa and Spottsylvania counties were operated successfully by the Virginia Lead & Zinc Corporation. The ores are handled by a 50-ton mill and flotation experiments are under way. Lead and zinc concentrates are produced.

The Austinville mine was operated by the Bertha Mineral Co., and tailings from the Bertha mine were treated at the Austinville mill, which resulted in a production of lead and zinc concentrates. The Ivanhoe Furnace Co., at Ivanhoe, Wythe County, shipped lead and zinc carbonate ores.

TIN.

By Adolph Knopf.

GENERAL STATEMENT.

The metallic tin estimated as recoverable from ore of domestic origin mined in 1917 was 110 short tons, a decrease of 30 short tons from the output of 1916. As in recent years, the bulk of the tin-bearing concentrate was obtained by dredges in Alaska, whose working season is limited by climatic conditions to less than 100 days a year. Part of the concentrate was shipped from Seattle to Singapore to be smelted and part was sent to the smelter at Perth Amboy, N. J.

The tin imported in 1917 as metal and metal in concentrate reached the record quantity of 77,866 short tons, or 57 per cent of the world's output for the year. The metal imported and entered for consumption was 72,166 short tons, and the domestic smelter output was 6,000 tons. The total supply of new tin available for consumption was, therefore, 78,000 tons. It is estimated that an additional 17,500 tons of tin became available by recovery from drosses and waste metals.

The unprecedentedly high prices of tin that prevailed during the latter part of 1917 and that still prevail have stimulated interest in the deposits of tin ore in the United States. References to the most recent published information on these deposits are given on pages 71–72. The known deposits are unfortunately small in number, and but few of these are commercially promising. Governmental stimulation, therefore, is not likely to add significantly to the domestic supply of tin. It is not probable that the country will achieve in 1918 an output much in excess of 200 tons of metallic tin from ores of domestic origin. The largest amount heretofore produced in any one year was 140 tons, or 0.2 per cent of the imports for that year.

The total quantity of tin produced from domestic ore in the United States, exclusive of Alaska, since the beginning of tin mining is 300 tons. Of this output the largest single item is the 135 tons produced in 1891 and 1892 by the Cajalco mine, in southern California, at a time when tin was at one-fourth its present price.

DOMESTIC PRODUCTION AND DEVELOPMENT.

ALASKA.[1]

Alaska produced 171 short tons of stream tin in 1917, a decrease of 61 tons from the preceding year. As this concentrate averaged 60 per cent of metallic tin, the output of recoverable metal is estimated at 100 tons. The York district, 100 miles northwest of Nome, yielded the bulk of the Alaskan output. Two dredges were operated, one working on Buck Creek and the other working on Grouse Creek downstream from the mouth of Buck Creek. There was a decrease in Alaskan shipments, owing largely to the fact that the bulk of the concentrate of one of the two principal operators, the American Tin Dredging Co., was not shipped before the close of the season and can not therefore be marketed before the reopening of navigation late in June, 1918. The York Dredging Co., which is working on Grouse Creek, finds that the concentrate won from the gravels is becoming increasingly heavier in pyrite as operations progress downstream from the confluence of Buck Creek, the source of the placer tin. This change is evidently due to the fact that the pyrite, being of lower specific gravity than cassiterite, has been carried farther downstream from the bedrock source of the minerals, which has been shown to be mainly in the hills at the head of Buck Creek.

---

[1] The writer is indebted to G. L. Harrington, of the U. S. Geological Survey, for first-hand information on recent developments in Alaska.

The reserves of gravel available for dredging are estimated to be sufficient for five years' operations at the present rate of exhaustion.

In addition to the tin recovered by the dredges, two men, using a string of three sluice boxes, took out a few tons of cassiterite from Iron Creek, a short tributary of Sutter Creek, the principal affluent of Buck Creek. The gravel worked contained about 15 pounds of cassiterite to the cubic yard, but this rich ground has been nearly worked out.

The rest of the Alaskan output of tin was a by-product of gold-placer mining on Sullivan and Woodchopper creeks, in the Hot Springs district, in the sector between Yukon and Tanana rivers.

At the Lost River lode tin mine, which is 15 miles southeast of the mouth of Buck Creek, little more than the annual assessment work was done. Of the few known tin lodes in the United States that hold out some promise of being profitably workable, this lode is among the more encouraging. The lode, called the Cassiterite lode, consists of a soft mineralized granite porphyry dike cut by stringers of cassiterite and wolframite, with which occur minor quantities of pyrite, arsenopyrite, zinc blende, and galena.[1] It has been partly opened by development work for a horizontal distance of 1,420 feet and a vertical distance of 410 feet above creek level.

In examining the concentrates obtained in placer-gold mining in the Yentna district, north of Cook Inlet, J. B. Mertie, of the United States Geological Survey, found that they contain as much as 20 per cent of cassiterite. This is a new locality for tin in Alaska, and the recognition that cassiterite occurs here should lead to systematic prospecting to determine its distribution and bedrock sources.

The total output of tin from Alaska since 1902, when tin mining began, is 867 short tons, almost all of which has been won from placers.

NEVADA.

F. L. Ransome, of the United States Geological Survey, recently made a brief visit to the tin deposits in northern Lander County, Nev., and has furnished the following note on recent developments:

> Efforts to find workable deposits of tin ore in place near the Izenhood ranch, north of Battle Mountain, have not proved successful, and no mining was in progress in

---

[1] Knopf, Adolph, Geology of the Seward Peninsula tin deposits: U. S. Geol. Survey Bull. 358, pp. 49-50, 1908.

October, 1917. A shaft 40 feet deep has been sunk in the rhyolite and shows some cassiterite (wood tin) as incrustations on the walls of small unfilled fissures, accompanied by specularite.

Cassiterite is apparently distributed through the rhyolite over an area of several square miles but has nowhere been found in sufficient quantity to be shipped as ore. At the time of visit an examination was in progress to determine whether the alluvial deposits that flank the tin-bearing rhyolite contain enough cassiterite to justify the building of a concentrating mill. Were water abundant and the general operating conditions more favorable, it is not unlikely that portions of the rhyolite itself might be successfully worked by crushing and concentration.

Some small masses extremely rich in cassiterite were found during 1917 in the Majuba Hill copper mine, operated by the Mason Valley Mines Co., in the northern part of the Trinity Range, in Humboldt County, Nev. Unfortunately, this material does not occur in commercial quantities. Under the microscope the material is seen to be an intimate intergrowth of cassiterite, tourmaline, and quartz. Thus it differs widely from the wood-tin ore of northern Lander County and probably belongs to an older epoch of mineralization. It is the first known occurrence of its kind in Nevada and doubtless merits further investigation.

OTHER STATES.

South Dakota.—There was some tin mining in the Black Hills,[1] the main activity being near Hill City, Pennington County, S. Dak. Early in 1917 the American Tin & Tungsten Co. worked the Cowboy mine, milling the ore in the old mill that the Harney Peak Tin Co. had built. Work ceased in April and a labor lien was put on the property by the employees. About 23 tons of concentrate carrying 50 per cent of tin were shipped to Perth Amboy as a result of these operations.

North Carolina and South Carolina.—In the Carolina tin belt some mill-run tests were made on the property of the United States Tin Co. near Lincolnton, N. C. At the Ross mine, near Gaffney, S. C., one man was employed in sluicing hillside wash derived from a tin-bearing pegmatite dike. A set of sluice boxes, without riffles and having a total length of 30 feet, was employed. Even with this crude equipment some cassiterite was profitably saved.[2]

Texas.—The El Paso tin mine, 14 miles north of El Paso, Tex., in the Franklin Mountains, which had been in the hands of receivers for several years, was sold to Davis Bros., of El Paso, late in 1917. This mine was last operated by the El Paso Tin Mining & Smelting Co. in 1910 and 1911, and about 8 tons of high-grade ingot tin was smelted in an oil-fired reverberatory furnace on the property.

SMELTING.

During 1917 the American Smelting & Refining Co.'s plant at Perth Amboy, N. J., produced 6,065 short tons of tin,[3] almost wholly from Bolivian concentrate. At the end of the year the plant was operating at the rate of 10,000 tons of tin a year and will probably produce 14,000 tons in 1918.

---

[1] Late in the year Messrs. Thomas Varley and R. R. Hornor, of the Bureau of Mines, examined the tin-bearing deposits of the Black Hills in order to determine whether these deposits can supply ore in commercial quantities.

[2] Information from H. G. Ferguson, of the U. S. Geological Survey.

[3] American Smelting & Refining Co. Nineteenth Ann. Rept., for 1917, p. 13, 1918.

The Williams Harvey Corporation endeavored to expedite the completion of its tin-smelting plant, which is being built on Jamaica Bay, Brooklyn, N. Y., but was seriously hindered by delay in the receipt of the necessary material. This plant also will smelt Bolivian concentrates. It is now expected that the plant will be ready for operation in July, 1918, and the estimated capacity is 10 tons of tin a day. A one-third interest in the corporation has been sold to Simon I. Patiño, owner of the Salvadora and Huanuni tin mines in Bolivia, thus insuring an adequate supply of concentrate.[1]

During 1917 somewhat less than one-fourth of the Bolivian exports of concentrate were shipped to the United States to be smelted and the remaining three-fourths were shipped to England for treatment. Manifestly it is an uneconomical use of shipping to transport this large quantity of concentrate to England to be smelted and then to ship the tin, or the equivalent in metal smelted from other concentrate, back to the United States, which is by far the world's largest consumer of tin.

Electric smelting was attempted at La Paz, Bolivia, in 1917, and 70 short tons of metal was produced, but many technical difficulties have hampered this pioneer enterprise.

The recently completed smelting plant at Arica, Chile, began operations in February, 1918, with a daily capacity of 15 tons of pig tin, and is expected to attain shortly a capacity of 30 tons. This plant is owned by the Compañía chilena de fundición de estaño (Chilean Tin Smelting Co.), a subsidiary of the Llallagua Tin Co.,[2] whose mines, 42 miles southeast of Machacamarca, Bolivia, supply the concentrate that is smelted.

Before the war a large proportion of the Bolivian concentrate went to Germany to be smelted. In 1912 Germany imported 17,961 metric tons from Bolivia and smelted 15,853 metric tons.[3] In 1913 Germany imported 18,652 metric tons of tin concentrate, of which 16,699 tons came from Bolivia.

IMPORTS.

The total importation of tin in 1917 was 77,866 short tons. This amount is the sum of two quantities—72,166 short tons of tin in bars, blocks, pigs, or grain or granulated, and 5,700 short tons of tin estimated as recoverable (63 ± per cent) from the 9,054 short tons of Bolivian concentrate imported during the year. The imports, as determined from the "general imports" (which in 1917 were slightly less than the tin entered for consumption) came from the following countries:

Tin imported into the United States in 1917.

	Short tons.		Short tons.
Straits Settlements	26,598	Australia	2,872
England	19,840	China	2,461
Dutch East Indies	15,843	Other countries	603
Bolivia (tin in concentrate)	5,700		
Hongkong	3,601		77,518

---

[1] National Lead Co. Ann. Rept. for 1917, p. 8, 1918.

[2] Commerce Repts., Mar. 23, 1917, p. 1092.

[3] Sonderabdruck aus den Vierteljahrsheften zur Statistik des Deutschen Reichs, Jahrg. 23, Heft I, p. 11, 1914.

The real origin of the tin is not wholly disclosed by this table, as the Straits Settlements produce no tin ore themselves but smelt concentrate from the Malay States, Siam, Billiton, and Singkep, South Africa, Australia, and even Alaska, all of which thus becomes Straits tin. The English tin also may be of diverse origin—from Bolivia, Nigeria, Portugal, as well as Cornwall—or may be reexports of Straits tin.

Tin imported and entered for consumption in the United States, 1906–1917.[a]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1906	50,477	$37,447,315	1912	58,016	$50,372,478
1907	41,257	32,074,263	1913	52,329	46,927,213
1908	41,267	23,923,560	1914	47,530	32,881,619
1909	47,662	27,558,546	1915	57,792	38,736,909
1910	52,528	33,913,255	1916	69,035	51,802,232
1911	53,527	43,346,394	1917	72,166	63,860,540

[a] Compiled from the records of the Bureau of Foreign and Domestic Commerce.

Tin ore imported into the United States, 1916–17.

Year.	Quantity (short tons).	Value.
1916	9,304	$4,036,821
1917	9,054	4,743,099

PRICES.

The average price of Straits tin in New York was 61.65 cents a pound for the year, as compared with 43.48 cents for 1916. The course of the market during the year is shown in the following table:

Average monthly prices, in cents per pound, of Straits tin in New York, in 1917.[1]

Month	Price	Month	Price
January	44.19	July	62.60
February	51.37	August	62.68
March	54.36	September	61.68
April	55.91	October	61.85
May	63.30	November	74.42
June	62.09	December[2]	85.35

The average price for the year in London was £237 13s. per ton of 2,240 pounds. The lowest price was £180¾ and the highest was £309.[3]

The course of the average yearly price of tin in New York since 1900 is shown in figure 1, together with the yearly output of tin. The prices are taken from Metal Statistics and the figures for output prior to 1913 from Mines and Quarries (London), Part IV, colonial and foreign statistics. These data have been plotted upon the so-called ratio chart in order that the two curves might be directly compared. On this chart if two curves run parallel they represent equal percentage rates of change.[1] From figure 2 it will be seen that the fluctuations in the price of tin have been much more violent than the fluctuations in output; that the long-time trend of the production curve shows that the production is slowly increasing (at the rate of 2.5 per cent yearly); that the price of tin is steadily rising, despite the cyclic fluctuations shown; and that the price of tin is rising at a rate somewhat faster than the rate of increase in the world's output of tin.

---

[1] Metal Statistics, 1918, p. 275.

[2] Market strictly nominal December 12–31; 86 cents used for the period as arbitrary basis in computing the month's average.

[3] Quin's Metal Handbook and Statistics, 1918, p. 92.

As the estimate of the world's output of tin in 1917 indicates, the extremely high prices that tin reached in the closing months of the year were not due to shortage of production, as the output probably slightly exceeded that of 1916. They were the results of shortage of shipping, of losses of tin in transit by submarine sinkings, and of restrictions upon the free movement of trade.

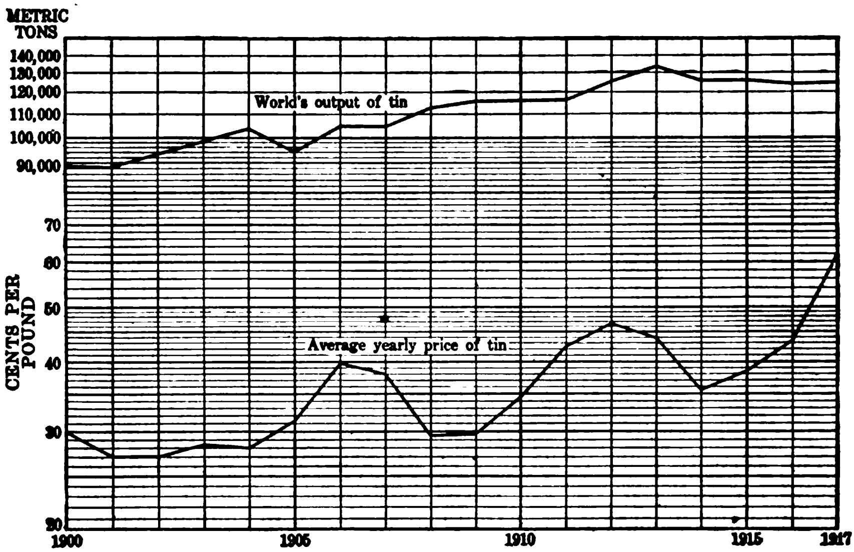


Figure 2.—Average yearly prices, in cents per pound, of Straits tin in New York, and world's output of tin, in metric tons, 1900–1917.

The complete blockade of the Central Empires has added 21,000 short tons of tin to the available supply of the rest of the world, 21,000 tons being the domestic consumption of Germany and Austria in 1913.[2] As shown by the rising prices, this additional supply has been easily absorbed, principally by the United States, which now consumes 57 per cent of the yearly output of tin.

WORLD'S OUTPUT.

The world's output of tin in 1917 is estimated to be 147,620 short tons, or a fair increase over that of 1916. The output in the various tin-producing regions from 1913 to 1917 is shown in the accompanying table. The figures given are based in the main on official reports, and represent as near as possible the recoverable metal contained in the "ore" or concentrate obtained during the calendar years. Where the average assay content of the concentrate is given in the original sources, 95 per cent of this assay value has here been used in computing the recoverable content of tin, in order to allow for the loss in smelting.[1]

---

[1] Fisher, Irving, The "ratio" chart for plotting statistics: Am. Stat. Assoc. Quart. Pub., vol. 15, p. 597, 1917.

[2] Metallgesellschaft, Statistische Zusammenstellungen, Jahrg. 20, pp. 78, 83, 1914.

World's output of metallic tin, 1913–1917, in short tons.

[Recoverable metal in ore and concentrate.]

	1913	1914	1915	1916	1917
Federated Malay States	56,140	54,930	52,380	49,130	44,610
British Protected Malay States	[a] 2,000	[a] 3,000	4,600	4,900	5,000
Bolivia [b]	29,500	24,600	24,100	23,500	31,200
Banca [c]	17,560	16,120	15,060	15,940	14,900
Billiton and Singkep [c]	5,840	6,720	7,430	7,480	8,000
China [d]	9,250	7,950	8,820	8,410	13,230
Siam	7,340	7,430	9,400	9,880	9,900
Nigeria	3,250	5,060	5,100	5,680	7,270
Australia	8,990	6,080	6,260	6,120	5,400
Cornwall	5,920	5,660	5,560	5,260	4,600
Union of South Africa	2,260	2,200	2,260	2,100	2,000
Other countries	1,500	1,500	1,500	1,500	2,000
	149,550	141,250	142,470	139,900	147,620
Total in metric tons	135,700	128,200	129,300	126,900	133,800

[a] Estimate.

[b] Commerce Reports, 1916, p. 973. The figures given there relate to exports of concentrate. The recoverable tin content of the concentrate is here computed on the basis of 60 per cent, which is undoubtedly somewhat low, especially for the exports since 1914. The output for 1917 is computed on the basis of 61 per cent of recoverable tin.

[c] The official statistics of the Dutch East Indies are given in part for fiscal years ending March 31.

[d] Exports from all ports (Ricard and Freiwald, Statistics of tin, Feb. 28, 1918).

The countries included under "Other countries" in the table produced in 1913 as follows: India, 340 tons; Japan, 320 tons; Swaziland, 200 tons; Spain, 160 tons; German Southwest Africa, 140 tons; Indo-China, 110 tons; Portugal, 100 tons; German Empire (Kingdom of Saxony), 60 tons[2]; United States. 50 tons; and Italy, 10 tons. A small quantity also was produced in Katanga Province, Belgian Kongo. In 1912 (the last year for which official statistics are at hand), the tin-smelting plant at Graupen, Bohemia, produced only 0.2 ton of tin from concentrate of domestic origin; in the same year 660 tons of tin ore carrying 1.5 per cent of tin was mined, but the bulk of it did not leave the mine from which it was produced.[3] The main change since 1913 in the production of the countries supplying minor quantities of tin is that in 1917 Portugal has probably taken the leading position.

The outstanding features of the world's production of tin in 1917 are the continued decrease in output of the Federated Malay States and the remarkable increase of production shown by Bolivia, which more than counterbalances the decrease in the output of Federated Malay States.

---

[1] The accuracy of statistics of output of metallic tin based on records of production is about 1 in 70, but this does not prevent statistical organizations, with few exceptions, from giving figures that are apparently significant to the last digit. This procedure implies for the figures of Bolivian output, for example, an accuracy of 1 in 25,000, but as a matter of fact neither the average assay content of the Bolivian concentrate nor the smelting loss are accurately known, and 60 per cent is customarily assumed to represent the equivalent in fine tin.

[2] Output for the year 1912 (Jahrb. Berg. u. Hüttenwesen im Königreiche Sachsen, Jahrg. 1913, pp. B 37, B 63). The output for 1913 was 190 tons of tin concentrate carrying about 40 tons of recoverable tin (Glückauf, Jahrg. 51, p. 117, 1915).

[3] Statistik des Bergbaues in Oesterreich, 1912, pp. 88–89, 1913.

The Federated Malay States[1] have long been the premier tin field, yielding as much as 50 per cent of the world's yearly output. They attained their greatest output in 1904, with 58,300 tons, though this output was nearly reached again in 1913, but since 1913 the production has been declining at an increasing rate. By 1917 the production had declined to 31 per cent of the world's total. This decline is attributed in part to a decrease in the labor supply, 224,804 laborers having been engaged in tin mining in 1913 and 138,056 in 1916. The output per laborer during this period has increased, however, from 0.25 ton a year to 0.36 ton, an increase caused in part by the installation of large hydraulic plants and dredges. Possibly the increase is due in part also to more continuous employment, but the statistics are not full enough to attempt to analyze them more closely. The more fundamental reason for the declining production is that the richer, more easily worked deposits are approaching exhaustion, that expensive installations will be necessary to work the lower-grade deposits profitably, and that restraining works will be required to impound the tailings in order to prevent damage to agricultural interests.

In 1914 mines under Chinese management produced about 76 per cent of the total output of the Federated Malay States; in 1915 the proportion had decreased to 72 per cent. At the beginning of 1915 three dredges were at work, but by the end of the year the number had increased to 10, which were capable of handling a total of 30,000 cubic yards a day. They recovered 3,117 tons of concentrate, equivalent to 2,180 tons of tin. In 1916 the number of dredges had further increased to 14. The largest dredging operator is Malayan Tin Dredging (Ltd.), which during the fiscal year 1916–17 worked 3,141,300 cubic yards of gravel. From this gravel 976 short tons of cassiterite concentrate were obtained, an average of 0.62 pound to the cubic yard, equivalent to 0.43 pound of metallic tin to the cubic yard. The profit for the year was £32,353, from which dividends of £24,200 were paid.[2]

It is not generally recognized that the Federated Malay States have become an important producer of lode tin and now rank next to Cornwall, the second leading country. In 1915 the Federation's output of lode tin was 3,730 short tons,[3] or 7 per cent of its total output of tin. The bulk of the world's tin won from lodes comes from Bolivia, Cornwall, the Federated Malay States, South Africa, and Australia, and in 1917 it amounted to about 42,000 short tons. Consequently, 31 per cent of the tin produced in 1917 came from lodes and 69 per cent from placers. In 1916 these proportions were 27 per cent and 73 per cent, respectively.[4]

The world's production of tin in 1916 is shown in Plate I. The locations of the centers of production in the countries enumerated in the table are given, except that in the illustration the outputs of the Federated Malay States, of the British Protected Malay States, and of Siam (all of which comes from the Siamese Malay States) have been added together and accredited to Malaya.

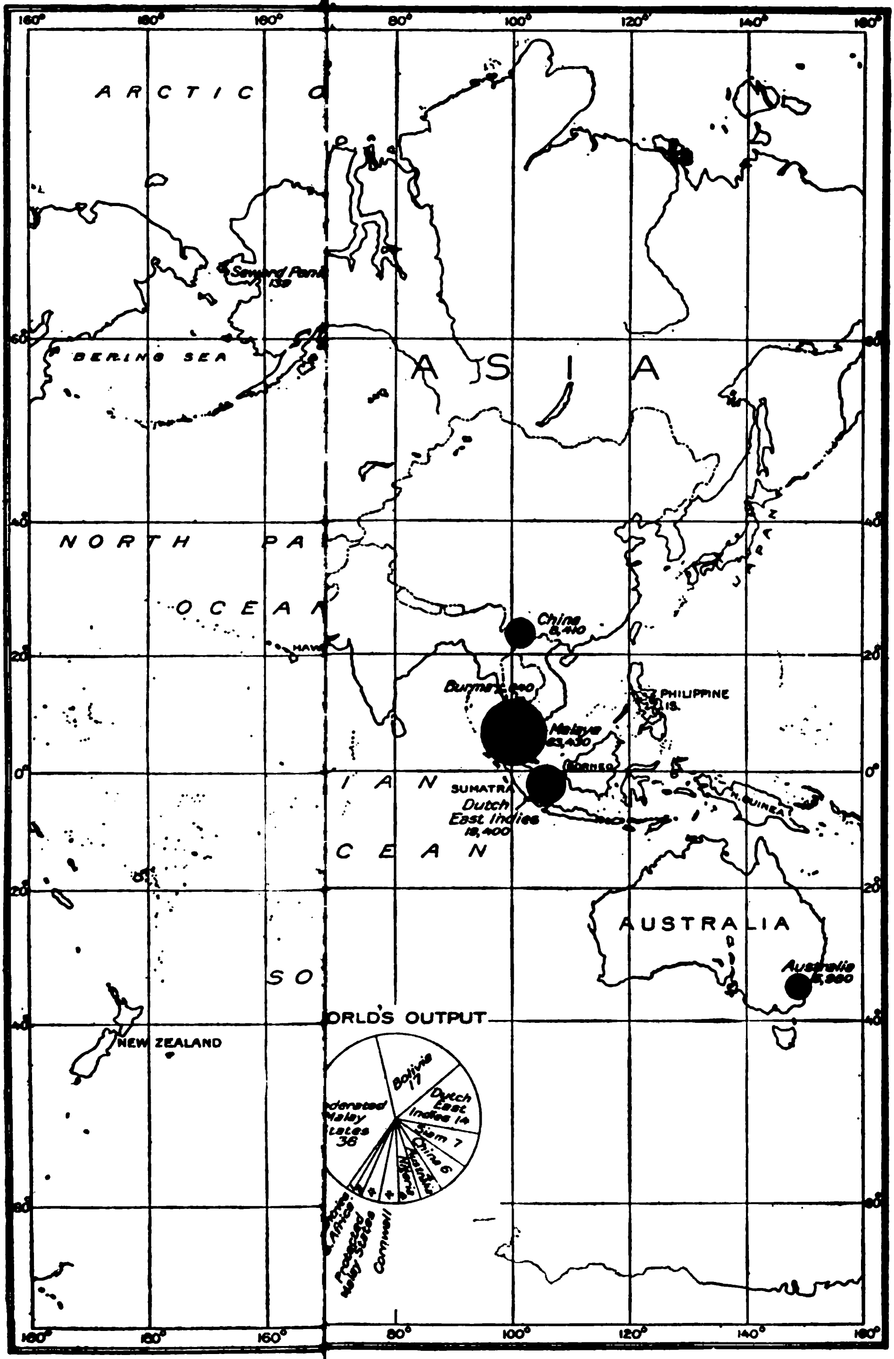
---

[1] Federated Malay States Mines Dept. Repts. for 1914, 1915, and 1916.

[2] Mining Jour. (London), vol. 119, p. 780, 1917.

[3] Federated Malay States Mines Dept. Rept. for 1915, pp. 11, 12, 13, 1916.

[4] The official figures for the lode output of the Federated Malay States, which were not available to the writer in 1917, have allowed him to refine the rough estimate given in the chapter on tin in 1916 (U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 620, 1917).


160°
180°
160°
80°
100°
120°
140°
160°
A R C T I C O
Seward Pen.
139
BERING SEA
ASIA
N O R T H P A
O C E A N
HAW
China
8,410
Burma
PHILIPPINE IS.
Malaya
63,430
BORNEO
I A N
SUMATRA
Dutch East Indies
18,400
N. GUINEA
C E A N
AUSTRALIA
Australia
5,360
S O
NEW ZEALAND
ORLD'S OUTPUT
Bolivia 17
Dutch East Indies 14
Siam 7
China 6
Australia
Nigeria
Federated Malay States 36
4
4
Union of S. Africa
Protected Malay States
Cornwall
60°
40°
20°
0°
20°
40°
60°

In 1917 almost exactly 50 per cent of the world's output of tin was produced within the British Empire.

PUBLICATIONS.

The following list includes the more recent publications relating to tin deposits in the United States. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Washington, D. C. Those marked "Exhausted" and the other publications can be consulted at the large public or university libraries of the country.

COLLIER, A. J., Tin ore at Spokane, Wash.: U. S. Geol. Survey Bull. 340, pp. 295–305, 1908. 30c.

The tin ore is cassiterite, which is apparently an original constituent of pegmatite. About 125 tons, containing 4 per cent of metallic tin, were extracted.

DARTON, N. H., U. S. Geol. Survey Geol. Atlas, Sundance folio (No. 127), 12 pp., 1905. Exhausted.

Gives a geologic map and structure sections of the Tinton (Nigger Hill) tin-bearing area of the northern Black Hills. The deposits are briefly described.

EAKIN, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 37–38, 1913. 20c.

Cassiterite occurs in gold placers and is recovered as a by-product of the gold placer mining.

——— Tin mining in Alaska: U. S. Geol. Survey Bull. 622, pp. 81–94, 1915.

A concise but full description of the geology of the Alaskan tin deposits, both lode and placer, and of the condition of the tin-mining industry. 30c.

FAIRBANKS, H. W., The tin deposits at Temescal, southern California: Am. Jour. Sci., 4th ser., vol. 4, pp. 39–42, 1897.

The tin deposits are at Cajalco Hill, near Corona, Riverside County, in southern California. The ore occurs in irregular shoots in quartz-tourmaline veins inclosed in granite. The principal vein was opened to a depth of 180 feet by two shafts 300 feet apart. The ore milled averaged 5 per cent of cassiterite.

FERGUSON, H. G., Tin deposits near Irish Creek, Va.: Virginia Geol. Survey Bull. 15-A, pp. 1–19, 1918.

The tin ore occurs in quartz veins, which are inclosed in a granite of a peculiar type, a hypersthene granodiorite. The ore probably forms shoots of variable size and content of tin, but the present condition of the workings and the extent of the developments are such as not to afford conclusive evidence on these features. The deposits are considered promising and to merit new exploration.

GRATON, L. C., Reconnaissance of some gold and tin deposits in the southern Appalachians: U. S. Geol. Survey Bull. 293, 134 pp., 1906. 15c.

The tin ore of the Carolinas occurs as an original constituent of pegmatite dikes. Detailed descriptions of the deposits are given.

HESS, F. L., Tin, tungsten, and tantalum deposits of South Dakota: U. S. Geol. Survey Bull. 380, pp. 131–163 (tin, pp. 134–149), 1909. 40c.

Describes the tin deposits of the Black Hills. The ore occurs in small shoots in pegmatite dikes and quartz veins.

HESS, F. L. and EVA, Bibliography of the geology and mineralogy of tin: Smithsonian Misc. Coll., vol. 58, No. 2, 408 pp., 1912.

Is an exhaustive bibliography of the geology, mineralogy, mining, milling, metallurgy, history, and statistics of tin.

HESS, F. L., and GRATON, L. C., The occurrence and distribution of tin: U. S. Geol. Survey Bull. 260, pp. 161–187, 1905. Exhausted.

Is a concise account of the geologic occurrence and distribution of tin deposits throughout the world.

INGALLS, W. R., Mineral Industry, vol. 5, p. 587, 1897.

Describes briefly the metallurgical operations at the Temescal or Cajalco Hill tin mine, in southern California. The concentrate, which averaged 65 per cent of tin, was smelted in a Cornish reverberatory furnace, California oil being used for fuel and New Mexico coal for reducing agent. The tin smelted was of good quality, and 135 tons were produced before the mine shut down [in September, 1892].

JOHNSON, B. L., Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, Alaska: U. S. Geol. Survey Bull. 442, pp. 246–250, 1910. 40c.

The gold-bearing gravels average 1 to 2 pounds of concentrate (chiefly wolframite and cassiterite, with some magnetite and garnet).

KEITH, ARTHUR, and STERRETT, D. B., Tin resources of the Kings Mountain district, North Carolina and South Carolina: U. S. Geol. Survey Bull. 660, pp. 123–146, 1917 (Bull. 660–D).

Describes the geology of the Carolina tin belt and the tin deposits, except some near Lincolnton, N. C. The development work done to date is described.

KNOPF, ADOLPH, Geology of the Seward Peninsula tin deposits: U. S. Geol. Survey Bull. 358, 72 pp., 1908. 15c.

The geology and tin deposits of the York district and of Ear Mountain, both in the western part of Seward Peninsula, Alaska, are described in detail.

——— Tin ore in northern Lander County, Nev.: U. S. Geol. Survey Bull. 640, pp. 125–138, 1916. 30c.

The recently discovered lode and alluvial tin deposits are described. The lode tin ore consists of wood tin associated with specular hematite, chalcedony, lussatite, tridymite, and opal. The veins occur in rhyolite flows of middle Tertiary age.

RICHARDSON, G. B., Tin in the Franklin Mountains, Tex.: U. S. Geol. Survey Bull. 285, pp. 146–149, 1906. Exhausted.

——— U. S. Geol. Survey Geol. Atlas, El Paso folio (No. 166), pp. 9–10, 1909. To be obtained from the Geological Survey for 5c.

Narrow quartz veins carrying cassiterite traverse post-Carboniferous granite.

SCHALLER, W. T., Cassiterite in San Diego County, Cal.: U. S. Geol. Survey Bull. 620, pp. 351–354, 1916. 30c.

A pocket of cassiterite crystals was found in a pegmatite dike.

UMPLEBY, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 74, 76, 1913. 40c.

Some wood tin has been found in the gravels of Silver and Panther creeks.

SILVER, COPPER, LEAD, AND ZINC IN THE CENTRAL STATES.

(MINES REPORT.)

By J. P. DUNLOP and B. S. BUTLER.

INTRODUCTION.

By J. P. DUNLOP.

The following is an account of the production of silver, copper, lead, and zinc in 1917 by the mines of the Central States, including Arkansas, Illinois, Kansas, Kentucky, Michigan, Missouri, Oklahoma, and Wisconsin. The territory thus embraced lies in the great interior valley province of the United States which extends from the Appalachian system to the Rocky Mountain front, excluding the Black Hills. Most of the mines are developed in the Paleozoic sedimentary rocks of this province, but the copper range of northern Michigan comprises lavas and intercalated sediments of pre-Cambrian age.

The statistics of production in these States have been compiled by the United States Geological Survey from confidential reports by each mine in operation and represent the quantity of metals recovered or paid for in the ore that was treated or sold during the year.

The method of marketing and recording the mine output in the lead and zinc regions of the United States differs from that employed in the Western States. In the Western States the miner usually sells his ore according to the assay content of metal at a certain price per unit. In the lead and zinc regions of the Central States, however, where the material sold is principally concentrates,[1] payment is made according to a basis price for a certain quality of concentrates. The details of this method are given in the pages devoted to Missouri in this report for 1914. The figures reported to the Survey by producers represent the quantity and assay content of concentrates sold and the amount received in payment. The total metal produced is calculated from the first two of these items.

The operators in Michigan report the quantity of concentrates produced and the actual recovery of copper from concentrates smelted. In any year the mines may produce more or less concentrates than are smelted during the same period. The copper content of concentrates produced but not smelted during the year has been estimated on the basis of the average copper recovery per ton for the year of the company producing it.

---

[1] In local usage the ore as mined is called "dirt" and the concentrates are classed as "ore." Where the capacity of a concentrating plant is given, such capacity is to be understood as based on a 10-hour shift unless otherwise stated.

In order to expedite the preparation and the printing of this report for the year 1917, much of the information relating to individual properties given under the district reviews for the various States has been eliminated. All essential data formerly given under the district reviews are included in the State reviews.

TENOR OF LEAD AND ZINC ORES OF THE CENTRAL STATES.

Much of the ore mined in the Western States is crude smelting ore; that is, it can be smelted directly without preliminary concentration. All but a very small portion of the ore from the Central States is of such tenor that it requires concentration. The only fair basis for comparison of the relative magnitude of mining operations in different States is that of quantity of crude ore, or "dirt," as it is usually called in the lead and zinc regions of the Central States. In the Joplin and upper Mississippi Valley regions the number of cans of ore hoisted is usually recorded and the approximate weight of the cans is generally known. Thus each company knows, in a general way, about what percentage of concentrates the run of mine is yielding. Knowing the total production of concentrates and the average yield of concentrates from crude ores, one can arrive at a close estimate of the crude ore raised. Only the actual operating companies have the data, however, and it was the practice of the Survey, in order to shorten the list of producers as much as possible, to send requests only to the owners of the mining land or the companies holding first leases and to depend upon them to report the whole production of the tract. Since 1911 not only the first lessees of the land have reported to the Survey, but also most of the sublessees have given data regarding both concentrates produced and "dirt" or ore milled. The tables of tenor of ore which follow in the sections devoted to the respective States show the comparative percentages for the last two years.

In Kentucky and southern Illinois the lead and zinc concentrates are recovered as by-products in the concentration of the fluorspar which they accompany, and it was not possible to make calculations of the metal content of the crude ore raised.

Tenor of copper, lead, and zinc ores of Central States, 1915–17.

State.	1915		1916		1917	
	Crude ore.	Metal content.[a]	Crude ore.	Metal content.[a]	Crude ore.	Metal content.[a]
	Short tons.	*Per cent.*	*Short tons.*	*Per cent.*	*Short tons.*	*Per cent.*
Arkansas	110,000	3.31	249,000	3.15	203,600	3.89
Illinois (northern)	316,000	2.35	288,100	1.60	327,340	1.81
Iowa	....	....	....	....	1,000	....
Kansas	709,400	2.42	774,400	1.98	903,400	2.82
Michigan	12,334,700	1.07	12,364,114	1.08	12,400,723	1.03
Missouri	[b]15,573,700	2.32	[b]18,664,024	2.18	17,024,000	2.24
Oklahoma	891,800	2.68	1,406,900	3.13	3,523,200	3.45
Wisconsin	1,934,000	2.77	3,066,500	2.36	3,014,800	2.57
	31,869,600	....	36,813,038	....	37,398,063	....

---

[a] The percentages given in this column represent the metal content of the ore in so far as it is recovered in the concentrates. In Michigan the metal so recovered is copper, in the other Central States the metals are lead and zinc, the relative proportions of which are shown in the table on another page and in the tables of tenor of ore given in the sections devoted to the respective States.

[b] A small quantity of copper ore included.

This table shows that from the copper, lead, and zinc mines of the Central States an increase of about 585,000 short tons of ore was treated in 1917, following an increase of 5,000,000 tons in 1916. The production of ore from the copper mines of Michigan increased only 36,000 tons, and the production of ore in Missouri decreased more than 1,640,000 tons, of which decrease 800,000 tons was due to the "sheet ground" mines. The mines of the disseminated lead district in southeastern Missouri increased their output about 420,000 tons. Other States which had a slightly decreased output of lead and zinc ore in 1917 were Arkansas and Wisconsin. The increase in 1917 in the other States was as follows: Oklahoma, 150 per cent; Kansas, 17 per cent; and Illinois, 14 per cent.

The low average tenor of the metal content of all crude ore mined in the Central States in 1917 is best shown by the fact that the average value of the total recoverable metal content was only $4.85 a ton of crude ore treated and that this value is $0.13 more than it was in 1916. The 24,997,340 tons of zinc, lead, and lead-zinc ores treated in the Central States in 1917 yielded lead and zinc concentrates which sold for $77,597,763, so that the mine operators realized an average of $3.10 a ton of ore mined and treated, against $2.68 a ton of ore realized in 1916. The increase was entirely in the value of the lead in the ores mined, for the average value of the zinc concentrates decreased in 1917 and there was an increase in the cost of labor, powder, fuel, and other supplies.

PRODUCTION.

The total value of the mine production of silver, copper, lead, and zinc in the Central States in 1917 was $180,249,464, an increase of $6,470,474, or about 4 per cent, compared with the value for 1916. The total value of the production of these metals for the years 1907 to 1917, inclusive, was $993,579,265, of which $422,221,935 was for copper, $341,861,422 for zinc, $226,145,624 for lead, and $3,350,284 for silver. Only in 1915 and 1916 has the value of the recoverable zinc exceeded that of copper.

SILVER.

The production of silver in the Central States in 1917 was 757,323 fine ounces, which, at the average price of 82.4 cents per fine ounce (16.6 cents higher than in 1916), was valued at $624,034, as compared with 852,380 fine ounces, valued at $560,866, in 1916. Nearly all the silver that is produced in the Central States is recovered incidentally in the production of other metals. Of this production 688,551 ounces came from the copper lodes of Michigan, a decrease of 28,089 ounces. About 25 per cent of the concentrates from lead ores mined in southeastern Missouri was desilverized and yielded nearly all the silver from that State recovered in 1917, and a small output of silver was also derived from copper ore and from copper concentrates recovered in dressing lead ores. The total recovery of silver from Missouri amounted to 61,586 ounces.

The lead-zinc-fluorspar deposits of the Kentucky-Illinois field also carry silver, and from the lead concentrates derived from Illinois 7,186 ounces of silver were recovered, an increase of 1,502 ounces.

COPPER.

The mine production of copper in the Central States in 1917 was from Michigan and Missouri, the first-named State, as in other years, contributing nearly the entire output, which amounted to 256,075,141 pounds. The copper production of Michigan in 1917 was 255,710,128 pounds, which, at the average sales price of 27.3 cents a pound, was valued at $69,808,865, as against a yield of 273,692,525 pounds, valued at $67,328,361, in 1916. The copper produced in Missouri in 1917, amounting to 365,013 pounds, valued at $99,649, was derived mainly from concentrates recovered in dressing the lead ores of southeastern Missouri, but a small part came from ore carrying copper and silver, which was shipped from the Racola mine in Washington County.

The total mine production of copper from Michigan and Missouri in 1917 was 18,003,584 pounds less than in 1916 and was about 21,000,000 more than the output of any other year, other than 1916, since 1907, when these figures were first compiled.

LEAD.

The mine production of lead in the Central States in 1917 was 269,656 short tons, which, rated at the average sales price for all grades for the metal for the year of 8.6 cents a pound ($172 a ton), was valued at $46,380,832, as compared with 251,405 short tons, valued at $34,693,890, in 1916. The output of lead increased 18,251 tons in 1917, and the value increased $11,686,942. In 1917 Missouri produced 87 per cent of the yield of lead in the Central States, and the recoverable lead content of galena and lead carbonate concentrates mined in Missouri in 1917 equaled 36.6 per cent of the refined primary lead recovered in the United States from domestic ore. Of the total output of lead in Missouri the "disseminated lead" district of southeastern Missouri produced 204,255 tons, an increase of 2,623 tons, again exceeding the yield from the Coeur d'Alene district of Idaho and retaining first place in production of lead in the United States. Southwestern Missouri was the next largest producing district in the Central States, with an output of 29,611 tons, or 1,845 tons less than in 1916. The Oklahoma production increased from 12,115 tons in 1916 to 26,358 tons in 1917, and the output of the Miami district in 1918 will exceed that of all regions other than southeastern Missouri.

The output of lead in 1917 from mines in Kentucky was less and that from mines in Arkansas, Illinois, Wisconsin, Iowa, and Kansas was considerably greater than it was in 1916. The total production of lead from mines in the southern Illinois-Kentucky region, Arkansas, Kansas, and the upper Mississippi Valley region amounted to only 3.5 per cent of the output of the Central States.

ZINC.

The production of zinc in the Central States in 1917, based on mine returns with a deduction for separating and smelting losse, was 310,471 short tons, valued at $63,336,084. The value is computed at 10.2 cents a pound (spelter $204 a ton), the average sales price reported by the smelters for all grades of the metal.

The output in 1917 was the largest recorded yield from mines in the Central States, exceeding that of the year 1916 by 45,170 tons in quantity. The value, notwithstanding the large increase in quantity, decreased $7,764,784. The production of spelter in the Central States was about 53 per cent of the total production of primary spelter from domestic ores in the United States in 1917.

The State of Missouri, with a decrease in output of 23,042 tons, was again in 1917 much the largest producer of zinc in the United States. Its production was 132,918 tons, against 155,960 tons in 1916. Wisconsin produced 59,742 tons in 1917, against 56,803 tons in 1916. Arkansas decreased in output from 6,815 tons to 6,691 tons, Kentucky from 1,096 tons to 751 tons. The production in Oklahoma increased from 28,754 tons in 1916 to 85,835 tons in 1917, or nearly 200 per cent. The output of zinc from Oklahoma in 1918 will doubtless exceed that of Missouri.

The production of zinc from Kansas mines increased from 12,448 tons in 1916 to 20,249 tons in 1917, and the mines located in northern Illinois produced 4,267 tons, an increase of 863 tons.

SUMMARY OF PRODUCTION BY STATES.

Mine production of silver, copper, lead, and zinc in the Central States in 1917.

State.	Silver.		Copper.	
	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Pounds.*	
Illinois	7,186	$5,921		
Michigan	688,551	567,366	255,710,128	$69,808,865
Missouri	61,586	50,747	365,013	99,649
	757,323	624,034	256,075,141	69,908,514
Total, 1916	852,380	560,866	274,078,725	67,423,366

State.	Lead.		Zinc		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Short tons.		*Short tons.*		
Arkansas	382	$65,704	6,691	$1,364,964	$1,430,668
Illinois	1,439	247,508	4,267	870,468	1,123,897
Iowa	34	5,848	18	3,672	9,520
Kansas	3,025	520,300	20,249	4,130,796	4,651,096
Kentucky	123	21,156	751	153,204	174,360
Michigan					70,376,231
Missouri	234,156	40,274,832	132,918	27,115,272	67,540,500
Oklahoma	26,358	4,533,576	85,835	17,510,340	22,043,916
Wisconsin	4,139	711,908	59,742	12,187,368	12,899,276
	269,656	46,380.832	310,471	63,336,084	180,249,464
Total, 1916	251,405	34,693,890	265,301	71,100,868	173,778,990

LEAD AND ZINC PRODUCTION, BY REGIONS.

The productive lead and zinc territory in the Central States naturally falls into seven regions, three of which are not limited to any single State. For statistical purposes the tables showing the production of lead and zinc by States are necessary and are so given. For practical purposes, however, it is desirable to compile the production by the natural regions irrespective of State lines.

The seven regions are, in order of importance of output, (1) the Joplin region, comprising the district in southwestern Missouri, southeastern Kansas, and northeastern Oklahoma; (2) southeastern Missouri, containing the great disseminated lead deposits; (3) the upper Mississippi Valley region, including all the lead and zinc mines in southwestern Wisconsin, Iowa, and northwestern Illinois; (4) northern Arkansas; (5) the Kentucky-Illinois fluorspar region in southern Illinois and northern Kentucky; (6) central Missouri; (7) the Arbuckle Mountain region in southern Oklahoma.

The southeastern Missouri region produced about 75 per cent of the lead output of the Central States and about 32 per cent of the production of primary lead recovered from domestic ore smelted or refined in the United States in 1917. The Joplin region produced 22 per cent of the lead and 77 per cent of the zinc of the Central States in 1917, and was much the largest producer of zinc in the United States, yielding about 41 per cent of the total spelter production from domestic ores in 1917, as against 35 per cent in 1916. The upper Mississippi Valley region produced 1.7 per cent of the lead and 20.6 per cent of the zinc in the Central States in 1917. The production of zinc in the northern Arkansas region amounted to about 2.1 per cent of that of the Central States in 1917.

The lower zinc content of the zinc concentrates produced in the upper Mississippi Valley region is clearly indicated by the fact that notwithstanding that the mines in the region yielded about 34 per cent of the total output of zinc concentrates of all classes the recoverable zinc content of such concentrates was only about 20.6 per cent of the recoverable zinc from mines in the Central States.

Mine production of lead and zinc in the Central States in 1917.

Region.	Concentrates.				
	Lead.[a]		Zinc.[b]		Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Joplin	75,744	$7,638,502	460,662	$31,126,468	$38,764,970
Southeastern Missouri[c]	306,473	30,070,995	479	23,489	30,094,484
Upper Mississippi Valley[d]	6,375	615,857	244,497	7,149,954	7,765,811
Northern Arkansas	474	47,598	17,969	708,409	756,002
Kentucky-southern Illinois	1,380	133,931	2,290	78,368	212,299
Arbuckle Mountain, Oklahoma			144	4,197	4,197
	390,446	38,506,878	726,050	39,090,885	77,597,763
Total, 1916	371,753	26,070,323	626,089	39,311,185	65,381,506

Region.	Metal.[f]				
	Lead.		Zinc.		Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Joplin	58,994	$10,146,968	238,768	$48,708,672	$58,855,640
Southeastern Missouri[c]	204,545	35,181,740	188	38,352	35,220,092
Upper Mississippi Valley[d]	4,767	819,924	64,027	13,061,508	13,881,432
Northern Arkansas	382	65,704	6,691	1,364,964	1,430,668
Kentucky-southern Illinois	968	166,493	751	153,204	319,700
Arbuckle Mountain, Oklahoma			46	9,384	9,384
	269,656	46,380,832	310,471	63,336,084	109,716,916
Total, 1916	251,405	34,693,890	265,301	71,100,868	105,794,758

[a] Includes both galena and lead carbonate concentrates.
[b] Includes sphalerite, zinc carbonate, and zinc silicate concentrates.
[c] Includes a small production from the central Missouri region.
[d] Includes Iowa, northern Illinois, and Wisconsin.

The volume of Mineral Resources for 1914 contains brief reviews of the history of lead and zinc mining in the Central States, the yearly production of each State for the period 1907 to 1914, inclusive, and historical notes and estimates of the total production of lead and zinc produced in each State before 1907. The separate chapter entitled "Silver, copper, lead, and zinc in the Central States in 1914" can be obtained on application to the Director, United States Geological Survey, Washington, D. C.

ARKANSAS.

By J. P. Dunlop.

PRODUCTION.

The value of the recoverable lead and zinc from Arkansas mines, which had increased from $801,754 in 1915 to $1,863,956 in 1916, was $1,430,668 in 1917. The decrease was caused almost entirely by the low price of zinc.

The production of galena increased considerably, while that of sphalerite decreased, though the total yield of these ores was small as compared with that of other regions. The shipments of zinc carbonate and zinc silicate concentrates in 1917 were slightly greater than in 1916.

Mine production of lead and zinc in Arkansas, 1907–1917.[a]

Year.	Ores.						Metal content.			
	Lead concentrates (galena).		Zinc concentrates.				Lead.		Zinc.	
			Sphalerite.		Silicate and carbonate.					
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1907	15	$800	538	$15,233	663	$16,210	12	$1,272	474	$55,982
1908	18	985	518	18,270	939	21,469	15	1,260	605	56,870
1909	30	1,800	896	33,948	98	2,736	24	2,064	510	52,080
1910	80	3,714	1,857	74,136	128	2,641	63	5,544	994	107,352
1911	80	4,321	1,407	40,425	183	4,239	64	5,760	664	75,696
1912	39	2,180	1,419	56,235	462	11,231	31	2,790	748	103,224
1913	23	1,179	594	16,916	680	15,050	18	1,584	478	53,536
1914	52	2,408	743	19,406	1,143	25,187	41	3,198	608	62,016
1915	79	4,961	606	41,341	7,925	408,079	63	5,922	3,209	795,832
1916	339	28,097	1,670	112,726	16,609	940,224	272	37,536	6,815	1,826,420
1917	474	47,593	916	57,824	17,053	650,585	382	65,704	6,691	1,364,964

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses of zinc but not of lead. In comparing the values of ore and of metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average sales price of all grades and that of zinc from the average sales price of all grades reported by the smelters.

Tenor of lead and zinc ore and concentrates produced in Arkansas in 1916 and 1917.

	1916	1917
Total crude ore ..short tons..	249,000	203,600
Total concentrates in crude ore:		
Lead..per cent..	0.13	0.23
Zinc..do....	7.35	8.82
Metal content of crude ore:		
Lead..do....	.11	.19
Zinc..do....	3.04	3.70
Average lead content of galena concentrates..do....	80.2	80.5
Average zinc content of sphalerite concentrates [a]..do....	57.1	58.4
Average zinc content of zinc silicate and carbonate [a]..do....	39.9	40.5
Average value per ton:		
Galena concentrates	$82.88	$100.41
Sphalerite concentrates	$67.50	$63.13
Zinc silicate and carbonate	$56.61	$38.15

[a] Includes some mixed carbonate and sphalerite.

NORTHERN ARKANSAS.

Considerable prospecting and some mining were carried on in northern Arkansas for many years, but the present development has mainly been accomplished since 1899, when there was a great rush to that field. The mines are principally in Boone and Marion counties and in the adjoining portions of Searcy and Newton counties, though there are also numerous mines and prospects in Baxter, Izard, Sharp, Lawrence, and other counties to the east, and deposits have been worked in Washington and Sevier counties, on the extreme western border of the State.

The ores are galena, sphalerite, and smithsonite, and the concentrates produced are generally of high grade and free from or very low in iron or lime. The sphalerite has frequently assayed 2 or 3 per cent above the price basis of 60 per cent metallic zinc content. The sphalerite and smithsonite are shown by analysis to contain appreciable quantities of cadmium, especially in a yellow variety of smithsonite, known locally as "turkey fat," which shows as high as 0.8 per cent of cadmium. The ore bodies occur in fissures or crevices, in fault breccias, and in solution breccias. The ore deposits are for the most part found in limestone of early Ordovician age, but some also are found in the Boone limestone of Mississippian (lower Carboniferous) age.

The number of concentrating plants that treated sphalerite was less than in 1916 and all the plants were operated intermittently. Some mixed sphalerite and zinc carbonate concentrates were sold and these shipments are partly given under sphalerite.

The estimated quantity of ore treated decreased from 249,000 tons in 1916 to 203,600 tons in 1917 and the average recovery of concentrates from such ore increased from 7.48 per cent to 9.05 per cent. This increase was the natural result of the decreased quantity of sphalerite ores and also of carbonate ores milled, especially in the Rush and other districts in Marion County.

Although there were several large operators, such as the J. C. Shepherd Mining Co., Morning Star Mining Co., Howard Mining Co., Lon Brown, Gloria Mining Co., and Lucky Dog Mining Co., in 1917, a large part of the production was from mines worked on a small scale. This is best shown by the fact that the total yield of all classes of concentrates, amounting to 18,443 tons, was derived from more than 150 mines or prospects.

The shipments of sphalerite, 916 tons, were made from 14 mines, and the largest shipment from any one mine was less than 200 tons. It is probable that the unsatisfactory condition of the market for zinc ore will result in a decreased output from Arkansas in 1918, although the development made and the mills erected in 1917 would, under normal conditions, result in a very much larger output.

Some improvement was made on the wagon roads in the mining districts, but long wagon hauls over poor roads still hamper mining in many sections.

The Cowan Barrens Development Co., which is prospecting by means of churn drilling the plateau lying between Rush and Yellville, is reported to have located good bodies of ore lying at depths between 120 and 200 feet. Three drill rigs are being used. The operators are very optimistic over the result of the drilling done and state that thorough tests will be made so that outside capital can be invested on a large scale with a reasonable assurance of a large supply of ore.

The Rush district in Marion County was in 1917, as in 1916, the largest producer of zinc concentrates, and Marion County produced more than half of all zinc concentrates from Arkansas. Boone, Newton, and Searcy counties had a larger production in 1917 than in 1916, and Searcy County with fewer mines in operation was a larger producer than Boone County. The assistance rendered to the Survey in obtaining statistics by R. W. Willett and J. H. Hand, of Yellville, and by other mine operators is gratefully acknowledged. It is to be regretted that many operators of mines in Arkansas, particularly the owners of small prospects, do not keep an accurate record of the quantity of dirt or ore mined and treated, the quantity of lead and zinc concentrates sold, the average assay of each class of concentrates, and the actual selling value of concentrates.

The shipments of lead concentrates from mines increased from 339 tons in 1916 to 474 tons in 1917. The production of sphalerite concentrates was 916 tons, or 754 tons less than in 1916, and the value decreased from $112,726 in 1916 to $57,824 in 1917. The sales of zinc carbonate concentrates increased in quantity from 16,609 tons in 1916 to 17,053 tons in 1917, but the value decreased from $940,224 to $650,585. The recoverable lead content of galena concentrates shipped amounted to 382 tons, valued at $65,704, and the recoverable zinc from zinc concentrates was 6,691 tons, valued at $1,364,964, in 1917. Mines in Marion, Boone, Newton, Searcy, Baxter, and Lawrence counties produced all the zinc concentrates shipped in 1917, and mines in Newton County produced 467 tons of the total shipments (474 tons) of galena concentrates. Mines in Lawrence County shipped 21 tons of sphalerite and 190 tons of zinc carbonate in 1917. The output was made by the Lucky Dog mill from dirt obtained from the Hoppe mine, the Louisiana-Arkansas Mining & Milling Co., the Mint Land Co., and the Raney mine now owned by the Seewald King Co.

Considerable development work was done at prospects in Baxter County and a crusher and hand jigs were installed on the Shiras land. The only zinc concentrates shipped in 1917 was a small quantity of hand cobbed carbonate from the Temple mine in the Buffalo district.

The shipments from Boone County were 3 tons of galena, 159 tons of sphalerite, and 3,458 tons of zinc carbonate. The shipments of zinc carbonate, which were about 900 tons more than in 1916, were mainly from mines in the vicinity of Zinc, especially from lessees on the Coon Hollow and Almy lands. Most of the sphalerite was derived from the K. M. mine of the Continental Mining Co., 3½ miles southeast of Harrison.

From mines principally in the Cave Creek district, in the eastern part, and the Ponca and Jasper districts, in the western part of Newton County, there were shipped 467 tons of galena, 16 tons of sphalerite, and 2,134 tons of zinc carbonate. Most of the galena and a large part of the zinc carbonate was shipped from Ponca. Although the new Confederate mill at Cave Creek was not operated in 1917, there was a large production of zinc carbonate shipped from the Bald Hill, North Slope, and other leases, on the lands of the American Lead, Zinc & Smelting Co. The Eleventh Hour lease on the Bennett land at Ponca was transferred to Victor Primrose and later sold by him to the Allied Mining Co. The Kilgore Mining Co. acquired the leases on the Baker and adjoining lands, which have been the largest producers of galena in Arkansas, and the production will probably be greatly increased.

From the mines in Searcy County there was shipped in 1917 8 tons of sphalerite concentrates and 4,183 tons of zinc carbonate, which was double the quantity shipped in 1916. About 65 per cent of the zinc carbonate came from the Big Hurricane mine of the J. C. Shepherd Mining Co., which was the largest producer of zinc ores in Arkansas in both 1916 and 1917. The other large producers were the Howard Mining Co., which purchased the Churchill, Evening Star, and Redwine mines in the Water Creek district, and the Lucky Dog Mining Co., near St. Joe.

The total shipments from mines in Marion County in 1917 were 4 tons of galena concentrates, 712 tons of sphalerite concentrates, and 7,083 tons of zinc carbonate concentrates, which was 6 tons of galena, 628 tons of sphalerite, and 2,209 tons of zinc carbonate less than in 1916.

The largest producers of sphalerite in Marion County in 1917 were the Bonanza mine in the Buffalo district, the Bear Hill mine near Dodd City, now owned by the Continental Mining Co., and the Silver Hollow mine at Rush Creek. A large number of mines in various districts shipped zinc carbonate concentrates, but all the larger producers of zinc carbonate, including the Morning Star, Philadelphia, Monte Cristo, Yellow Rose, and Edith, are in the Rush district. Other mines, which are equipped with mills and which made good shipments, were the Liberty on the Willett land at Hall Mountain, Sure Pop No. 1 and Sure Pop No. 2 on Water Creek, and the Standard at Helva.

ILLINOIS.

By J. P. Dunlop.

PRODUCTION.

In the chapter entitled "Silver, copper, lead, and zinc in the Central States" of Mineral Resources for 1914 were given a historical review and a bibliography of the literature relating to the mining of lead and zinc in the northern and southern districts of the State of Illinois. Estimates were also given of the total quantity of concentrates and metal produced to the end of 1914.

Mine production of lead and zinc in Illinois in 1917.[a]

District.	Ores.				Metal content			
	Lead concentrates (galena).		Zinc concentrates (sphalerite).		Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Northern Illinois.....	788	$78,666	18,221	$477,003	594	$102,168	4,267	$870,468
Southern Illinois.....	1,196	118,516	....	....	845	145,340	....	....
	1,934	197,182	18,221	477,003	1,439	247,508	4,267	870,468
Total, 1916.....	1,550	113,604	15,211	461,045	1,072	147,936	3,404	912,272

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses of zinc but not of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily sales price (all grades) and that of zinc from the average sales price (all grades) reported by the smelters.

Mine production of silver in southern Illinois, 1907–1917.

	Silver.		Lead concentrates, silver bearing.			Silver.		Lead concentrates, silver bearing.	
	Quantity (fine ounces).	Value.	Quantity (short tons).	Ounces of silver per ton.		Quantity (fine ounces).	Value.	Quantity (short tons).	Ounces of silver per ton.
1907......	2,852	$1,882	497	5.74	1913.....	3,541	$2,139	507	7.00
1908......	2,051	1,087	359	5.71	1914.....	2,112	1,168	308	6.86
1909......	1,011	526	250	3.90	1915.....	3,864	1,959	641	6.03
1910......	2,022	1,092	398	5.08	1916.....	5,684	3,740	874	6.50
1911......	3,036	1,609	482	6.25	1917.....	7,186	5,921	1,239	5.80
1912......	4,731	2,909	748	6.31					

Tenor of lead and zinc ore and concentrates produced in Illinois, 1916 and 1917.

	1916	1917
NORTHERN ILLINOIS.		
Total crude ore..........short tons..	288,100	327,340
Total concentrates in crude ore:		
Lead..........per cent..	0.23	0.24
Zinc..........do....	5.28	5.56
Metal content of crude ore:		
Lead..........do....	.16	.18
Zinc..........do....	1.44	1.63
Average lead content of galena concentrates..........do....	68.2	75.4
Average zinc content of sphalerite concentrates..........do....	27.4	29.3
Average value per ton:		
Galena concentrates..........	$69.30	$99.83
Sphalerite concentrates..........	$30.31	$26.18
SOUTHERN ILLINOIS.		
Average lead content of galena concentrates..........per cent..	70.0	70.7
Average value per ton of galena concentrates..........	$76.38	$99.10

The lead concentrates produced in southern Illinois are recovered in concentrating the fluorspar. To speak of the total crude ore raised as crude lead ore would be misleading. No attempt has been made, therefore, at calculating the quantity or the tenor of the crude ore.

The value of the mine production of silver, lead, and zinc in Illinois in 1917 was $1,123,897, as compared with $1,063,948 in 1916. The lead concentrates produced amounted to 1,984 short tons, which was 434 tons more than in 1916, and the recoverable lead content increased from 1,072 tons in 1916 to 1,439 tons in 1917.

The output of sphalerite concentrate increased from 15,211 tons in 1916 to 18,221 tons in 1917, the recoverable zinc content of the concentrates increased from 3,404 tons in 1916 to 4,267 tons in 1917, but the value decreased $41,804.

The silver recovered from lead concentrates amounted to 7,186 fine ounces, valued at $5,921, against 5,684 fine ounces, valued at $3,740, in 1916.

The lead and zinc deposits of Illinois fall into two distinct regions marked by different mineral association and structural environment. Those of southern Illinois belong to the Kentucky-Illinois fluorspar district; those of northern Illinois belong to the upper Mississippi Valley region.

NORTHERN ILLINOIS.

The lead and zinc mines of northern Illinois are all in Jo Daviess County, the extreme northwestern county of the State. The ores have the same structural relations as in the upper Mississippi district generally, that is, they occur disseminated through the limestone, or in openings in it called "crevices," "pitches," or "flats," depending on their attitude to the horizontal. These openings have in general, an east and west trend, known as their "range." The ore bodies are sometimes continuous for long distances along these "ranges," which for that reason largely control the prospecting, both by shafts and by drilling. The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age.

The ores are galena, smithsonite, and sphalerite, though the two latter are much less common now than formerly, when the deposits worked were mostly shallow and above water level. In early years the galena ores only were mined and the ore was taken from shallow pockets in quantities ranging from a few tons to several thousand.

Although the lead output of northern Illinois, Wisconsin, and Iowa has been large in the past and the ores have been smelted near the mines,[1] the output in recent years has been comparatively small and no ores have been smelted in those States.[2] The galena is practically nonargentiferous, and the zinc ores are not known to contain cadmium. Iron pyrites is very commonly associated with the ores, generally in such quantity as to necessitate roasting and magnetic separation.

As none of the operators in the Sand Prairie district or in the Elizabeth district reported any production in 1917 the entire output of northern Illinois is included under the Galena district, which comprises the mines in the vicinity of Fever River to the Wisconsin State line. The production of lead concentrates was 788 tons, valued at $78,666, as compared with 676 tons, valued at $46,853, in 1916.

---

[1] Cox, G. H., Lead and zinc deposits of northwestern Illinois: Illinois Geol. Survey Bull. 21, p. 14, 1914.
[2] Pulsifer, H. B., History of lead smelting in Wisconsin: Min. and Eng. World, May 2, 1914, p. 821

There were 18,221 tons of sphalerite concentrates, valued at $477,003, produced in 1917, an increase of 3,010 tons in quantity and of $15,958 in value.

The tonnage of crude ore mined increased from 288,100 tons in 1916 to 327,340 tons in 1917. The average recovery of zinc concentrates from the ore milled increased 0.29 per cent, and the percentage of lead was slightly greater than in 1916.

The average zinc content of the sphalerite concentrate increased from 27.4 per cent in 1916 to 29.3 per cent in 1917.

The largest production of lead and zinc concentrates in northern Illinois in 1917, as in 1916, 1915, and 1914, was derived from the old Marsdon-Black Jack mine of the Mineral Point Zinc Co. The mill has a capacity of 600 tons in 24 hours and is driven by electric power. The mine is equipped with a steel head frame and a double-compartment mill shaft and the ore is hoisted in skips. The Graham mine, of the Vinegar Hill Zinc Co., was the second largest producer. This mine was first operated in 1917 and is equipped with a 250-ton concentrating plant, which milled ore hoisted through a 200-foot shaft.

The Bartell & Sherrill Mining Co. had a considerable output of lead mined at 45 feet, which was also from a lease on the Graham land. The North Unity mine of the Vinegar Hill Zinc Co., on the Curran land, had a production nearly as large as that of the Black Jack and Graham mines. The shaft at this mine is 175 feet deep and the mill has a capacity of 20 tons an hour.

The Birkbeck mine and 150-ton mill were operated only for about three months and the mill was dismantled. The Eadie and Merry Widow mines shipped high-grade galena concentrates. New equipment was placed on both properties. The surface equipment of the Merry Widow mine was destroyed by fire in February, 1918, and the property is reported to have been sold to the Burr Mining Co.

The Little Corporal mine, of the Field Mine & Milling Co., had a small output before the property was abandoned by the lessees.

SOUTHERN ILLINOIS.

The lead and zinc deposits of southern Illinois are found in Pope and Hardin counties in rocks of Mississippian age in the northern extension of the Kentucky-Illinois fluorspar district.

The principal product of the mines in recent years has been fluorspar, and the yield of galena is small compared with the output from other districts in the Central States. The total production of galena concentrates for southern Illinois, 1906 to 1917, inclusive, has been 6,515 tons, most of which has been shipped from the Fairview and Rosiclare mines. The shipments of zinc ores from the district have been comparatively small and scattered. The only recorded shipments of zinc carbonate were made from the Empire mine in 1903 or 1904, and in 1906 four companies made shipments aggregating 103 tons.

The structural relations and the mineralogic association are similar to those of the deposits of western Kentucky and in striking contrast to those of the deposits of northern Illinois. The ores occur in fissure veins, in association with jointing and faulting. The mines have been worked to depths of 300 and 500 feet without disclosing any decrease in the dimensions of the ore bodies. Dikes and sheets of lamprophyre and dikes of mica peridotite occur in the vicinity, but not in direct connection with the ore deposits. Galena is the most important metallic mineral. Formerly, and nearer the surface, large bodies of galena were worked, but it is at present produced incidentally in the concentration of the fluorspar. For this reason it would be misleading to give the quantity of crude ore. As the district is not reached by railway, the product of the mines is dependent on river transportation.

The galena of southern Illinois is notably argentiferous as compared with the rest of the Mississippi Valley ores, the silver content being as much as 14 fine ounces per tone of lead concentrate and averaging for the last seven years from 5 to 7 fine ounces per ton of lead concentrate. Sphalerite, or zinc blende, is the next important metallic mineral, but it occurs much less plentifully than galena. It is recovered as zinc middlings in the concentration of the fluorspar. The difficulty of making a clean separation of the zinc middlings has kept down the production of zinc. None has been sold from southern Illinois in the last nine years. The principal vein minerals are fluorspar, calcite, and barite.

The shipments of galena concentrates increased 322 tons in quantity, and the silver content recovered in treating the concentrates increased from 5,684 ounces in 1916 to 7,186 ounces in 1917. The average lead content of the concentrates increased from 70 per cent in 1916 to 70.7 per cent in 1917. The average silver content per ton recovered from lead concentrates decreased from 6.50 ounces in 1916 to 5.80 ounces in 1917.

The Fairview Fluorspar & Lead Co., which was much the largest producer of galena, operates on the Good Hope vein, which was first developed in 1862. The ore mined in 1917 was hoisted through three shafts, which are respectively 500, 400, and 300 feet in depth. This company also took over and operated the Franklin mine, which is about 5¼ miles from Marion, Ky.

The Rosiclare Lead & Fluorspar Co. operates on an ore body which is probably continuous with that of the Fairview. The main shaft at the Rosiclare has reached a depth of 520 feet, and the other two shafts operated are 300 feet and 400 feet deep. The steel and concrete mill, entirely fireproof, is designed to handle 500 tons a day and is provided with special facilities for saving the lead and zinc both by jigs and by tables.

IOWA.

By J. P. Dunlop.

The lead and zinc deposits of Iowa extend along Mississippi River for nearly 80 miles, in Dubuque, Clayton, and Allamakee counties. They are found in the Galena dolomite, of Ordovician age.

In early days the Dubuque mines were the most important source of lead in the United States, and in later years the mines, especially those in the vicinity of Durango, yielded considerable quantities of zinc-carbonate ore. Nearly all this earlier mining was done above water level, and only within the last few years has there been much attempt to mine below water level. Therefore the production, particularly of zinc-blende ore, for these years, though small, is noteworthy, since it represents the attempt to mine at deeper levels.

The ore deposits of the Dubuque district occur in crevices and in caves or "openings" along these crevices. Of these openings there are five or six, the "top," "middle," and "third" being the most prolific of ore. The "flats" and "pitches," common in the Wisconsin mines, have been found in only one or two places in Iowa. The crevices have an east-west trend and sometimes extend considerable distances, being mined at different places, in which case they are known as "ranges."

The estimated output of 60 tons of zinc carbonate and 43 tons of galena concentrates in 1917 was derived from shallow workings by a number of small operators, Weston & Anderson being the largest producers. The estimated recoverable metal content of the concentrates shipped was 34 tons of lead, valued at $5,848, and 18 tons of zinc, valued at $3,672.

KANSAS.

By J. P. Dunlop.

PRODUCTION.

Production of lead and zinc in Kansas, 1917.[a]

District.	Ores.					
	Lead concentrates.		Zinc concentrates.			
	Galena.		Sphalerite.		Carbonate and silicate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Badger-Peacock	99	$9,394	2,264	$186.022	....	....
Lawton-Waso	116	12,138	5,658	408,070	....	....
Blue Mound-Baxter Springs	1,005	101,292	12,070	849,351	....	....
Galena	2,709	246,163	18.774	1,229,725	21	$930
	3.929	368,987	38,766	2,673,168	21	930
Total, 1916	2,217	162,103	24,277	1,324,069	5	196

District.	Metal content.			
	Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Badger-Peacock	79	$13,588	1,206	$246,024
Lawton-Waco	92	15,824	3,060	624,240
Blue Mound-Baxter Springs	817	140,524	6,595	1,345,380
Galena	2,037	350,364	9,388	1,915,152
	3,025	520,300	20,249	4,130,796
Total, 1916	1,648	227,424	12,448	3,336,061

[a] In calculating the metal content of the ores from assays, allowance has been made for smelting losses of zinc but not of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average sales price for all grades and that of zinc in 1916 and 1917 from the average sales price reported by the smelters.

Tenor of lead and zinc ore and concentrates produced in Kansas, 1916 and 1917.

	1916	1917
Total crude ore....short tons..	774,400	903,400
Total concentrates in crude ore:		
Lead....per cent..	0.29	0.43
Zinc....do....	3.15	4.29
Metal content of crude ore:		
Lead....do....	.20	.33
Zinc....do....	1.73	2.49
Average lead content of galena concentrates....do....	74.3	77.0
Average zinc content of sphalerite concentrates....do....	57.0	58.0
Average zinc content of zinc silicate and carbonate....do....	38.0	40.0
Average value per ton:		
Galena concentrates....	$73.12	$93.91
Sphalerite concentrates....	$75.13	$68.96
Zinc silicate and carbonate....	$39.20	$44.29

The lead and zinc deposits of Kansas, so far as developed, are limited to the southeastern portion of the State, in Cherokee County. They comprise the western extension of the ore deposits of the Joplin region and display the general characteristics of that area, except that here typical sheet-ground deposits have not been extensively developed. The ores are galena and lead carbonate, sphalerite or zinc blende, and zinc carbonate and silicate. The galena is practically nonargentiferous, carrying but a small fraction of an ounce of silver to the ton of lead concentrates.

It is difficult to obtain the production for early years or to segregate the Kansas ores from those produced in the adjoining portion of the Joplin region in Missouri. If to the figures obtained and published by the State Geological Survey of Kansas for the years 1886–1903 [1] are added those for the years 1904–1917, published by the United States Geological Survey, a total output of 1,084,247 tons of zinc concentrates and of 153,368 tons of lead concentrates is shown as the approximate production of Kansas for the years 1886–1917, inclusive.

The value of the mine production of lead and zinc in Kansas in 1917 was $4,651,096, against $3,563,488 in 1916.

The value of the recoverable lead in galena concentrates shipped from Kansas mines in 1917 was $520,300, more than double that of 1916. The production of lead concentrates increased from 2,217 tons in 1916 to 3,929 tons in 1917, and the metal content from 1,648 tons to 3,025 tons. The percentage of lead concentrates in crude ore milled increased from 0.29 per cent in 1916 to 0.43 per cent in 1917. This increase was mainly due to the working of new mines near Blue Mound and to a slightly increased output from small diggings worked under the stimulus of the much higher average price of galena in 1917.

The average lead content of the galena concentrates sold was 2.7 per cent more in 1917 than in 1916, and the average price received for such concentrates was $93.91 a ton, against $73.12 in 1916.

The production of zinc carbonate and silicate was only 21 tons, valued at $930, or 16 tons more than in 1916.

The production of sphalerite concentrates in 1917 was 38,766 tons, valued at $2,673,168, an increase of 14,489 tons in quantity and of $849,099 in value, as compared with 1916. The average zinc content of the sphalerite concentrates shipped was 1 per cent more in 1917 than in 1916. Owing to the much richer ore mined in the new Waco and Blue Mound districts, the total per cent of sphalerite concentrates recovered from crude ore treated in Kansas increased from 3.15 per cent in 1916 to 4.29 per cent in 1917.

---

[1] Haworth, Erasmus, and others, History, geography, geology, and metallurgy of Galena-Joplin lead and zinc: Kansas Univ. Geol. Survey, vol. 8, 1904.

The production of the Badger-Peacock district in 1917 was about double that of 1916, and many leases west of Badger, near Shawnee, were drilled and a few shafts were sunk. Included among the operators in this section were T. R. Harrington, Badger Mining & Development Co., Shanklin & Neff, and the Chanute Spelter Co. The output of sphalerite in the Lawton camp in 1917 was less than in 1916, as the working level of the Eastern Zinc & Lead Co.'s property was being lowered and considerable low-grade dirt was hoisted and milled. Drilling resulted in the discovery of good ore bodies at depths ranging from 215 to 240 feet, and from 270 to 315 feet. The maximum depth of the ore mined in 1917 was 165 feet. Although the only producing mines in the Waco district, lying partly in Kansas and partly in Missouri, were the Acme, the Liberal, and Waco No. 1, the production was greater than that of the older Lawton camp. Waco was one of the most active camps in the Joplin region. The Waco Mining Co. was the largest producer of sphalerite in 1917, though its No. 2 mill was not completed until 1918.

The Butte-Kansas Mining Co.'s mill, on the Kansas side of the Waco field, was destroyed by fire a few days after it was completed. The mill has been reconstructed and the Acme mine has been purchased and will be equipped with a large mill. The Liberal mine, which has been purchased by the Freehold Oil & Gas Co., had a large output from the small quantity of dirt milled. Many leases on the Irwin, Hurlbut, Bennett, Houston, Nicholls, Dobbs, and other lands were drilled and practically all the land in the vicinity of Waco was leased. Some of the lessees and operators are Thomas Coyne, T. J. Franks, High Five Mining Co., Blue Rock Mining Co., and Noel Mining Co.

The production of lead concentrates in the Galena district in 1917 was 2,709 tons, valued at $246,163, as compared with 2,136 tons, valued at $155,389, in 1916. The shipments of zinc concentrates (all of which was sphalerite, except 21 tons) amounted to 18,795 tons, a decrease of only 658 tons; but, owing to the lower prices paid for zinc concentrates, the total value of the zinc concentrates was $216,864 less in 1917 than in 1916. The metal content of the lead concentrates was 2,037 tons in 1917, against 1,584 tons in 1916.

The average zinc content of sphalerite sold in the Galena district in 1917, according to the reports of the operators, was 55.6 per cent, which is a very close agreement with the average zinc assay of more than 2,600 sample lots made by A. J. Lusk, of Galena. The assays made by Lusk were used by buyers and sellers in settlements for ore and represent the average assay of sphalerite shipped from Galena and other adjacent camps. The average assay of 2,637 lots, regardless of the weight of each lot sold, was 56.33 per cent zinc and 2.21 per cent iron.

Many of the small leases at Galena are not equipped with concentrating plants, and a considerable part of the production is milled at custom mills or sold to chatters. Early in the year these custom plants had an ample supply of ore, but the lower prices during the last part of the year caused many of the small mines to close.

There were not many transfers of mining property and only a few new producing mines were developed in 1917. There was, however, more drilling done than in former years and ore bodies at much lower levels than any now opened were located. The Wayland Mining Co. completed a 300-foot shaft and also did considerable drilling on the Wyandotte and other leases. Ore has been found by drills at a depth of about 300 feet on the Williams, Empire, Southside, Page & Cobb, Schermerhorn, and Giessinger lands.

The activity in that part of Cherokee County, Kans., which was caused by the progressive northerly development of the Miami field, continued throughout 1917. Most of the land lying north of the Oklahoma-Kansas State line and west and north of Baxter Springs had been leased in 1916, and the lessees or the sublessees utilized several hundred drill rigs to prove their holdings. Holes were drilled 8 or 9 miles west of Baxter Springs and to the north as far as Crestline and Columbus. The only producing properties in 1917 were the Blue Mound and Blue Diamond mines of the Blue Mound Mining Co., and the Barr mine of the Vinegar Hill Zinc Co., although many new shafts were sunk and mills were erected. The shipments for the new district amounted to 1,005 tons of galena and 12,070 tons of sphalerite, and the average recovery in concentrates from dirt milled exceeded 8 per cent. In the territory north of the Oklahoma State line and west of Blue Mound, shafts are down and concentrating plants erected at the following mines: Inspiration (Huttig Lead & Zinc Co.), Webber (Commerce), Mineral State, Southern, Thomas (United Zinc Smelting Corporation), Kansouri, National, D'Armand, Silver Fox, Kanoma, and Broom Factory (Commerce). A flotation plant was also erected by Fred De Mier on the Blue Mound lease.

West and north of Baxter Springs, shafts have been sunk and mills were built or will be erected by the Quaker Valley Mining Co., Chanute Spelter Co., and the Pershing Mining Co. North of Hockerville and southwest of Baxter Springs there was much prospecting, and mills were erected or shafts sunk by the Lucky O. K. Mining Co., Admiralty Zinc Co., Buckshot Mining Co., and others.

The Southwest Missouri Electric Railway completed its extension from Galena, Kans., as far as Hockerville, early in 1918. The Oklahoma, Kansas & Missouri Interurban Railway reaches as far as Treece, near Blue Mound, and can quickly be extended so as to furnish transportation to the mines north and west of Treece.

KENTUCKY.

By J. P. Dunlop.

PRODUCTION.

Lead and zinc deposits are found in both central and western Kentucky. None of the mines in Franklin, Mercer, Scott, Owen, or Henry counties, in the central districts, reported any lead or zinc concentrates shipped in 1917. The mines in the fluospar region of western Kentucky are chiefly in Crittenden, Caldwell, and Livingston counties and form a continuation of the southern Illinois lead and zinc region. The earliest available records of the occurrence of fluorspar and the associated galena in the Kentucky-Illinois region appeared in the first, second, and third volumes of the American Journal of Science, published in 1818, 1820, and 1821.[1]

The presence of zinc blende was recognized in 1854–1857 during the first geological survey of the State of Kentucky by David Duke Owen and his assistant, Sidney S. Lyon. The first lead smelter using galena from Kentucky was erected by the River Valley Mining Co. at the Royal mine[2] about 1870.

Considerable quantities of galena ores have been produced in former years, but at the present time lead is obtained solely as a by-product in the recovery and concentration of fluorspar, which is the principal economic mineral. The galena recovered is argentiferous, the silver content varying from a very small quantity to more than 3 ounces a ton, but no recovery of this silver content has been reported by the smelters during the last six years. The lead concentrate shipped in any one year from Kentucky does not necessarily represent the actual recovery of lead from fluorspar mined in that year, for, being merely accessory to the fluorspar and produced in small quantities, it is frequently held until a considerable quantity has accumulated or until lead prices are high.

Production of lead and zinc in Kentucky, 1907-1917.

Year.	Ores.						Metal content.			
	Lead concentrates (galena).		Zinc concentrates.				Lead.		Zinc.	
			Sphalerite.		Zinc carbonate.					
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1907	54	$2,850	....	....		....	34	$3,604	....	....
1908	....	....	....	....	....	....	....	....	....	....
1909	12	620	....	....	150	$1,701	10	860	64	$6,912
1910	56	1,980	....	....	30	300	41	3,608	6	648
1911	....	....	....	....	467	10,604	....	....	158	18,012
1912	151	6,827	498	$25,391	750	16,006	106	9,540	491	67,758
1913	40	1,422	198	5,206	696	13,811	22	1,936	327	36,624
1914	26	800	27	1,120	644	12,168	16	1,248	230	23,460
1915	370	17,103	....	....	2,172	106,079	251	23,594	764	189,472
1916	227	16,868	125	6,407	2,923	126,875	153	21,114	1,096	293,728
1917	184	15,415	....	....	2,299	78,368	123	21,156	751	153,204

The shipments of zinc carbonate decreased from 2,923 tons, valued at $126,875, in 1916 to 2,299 tons, valued at $78,368, in 1917. The estimated recoverable zinc content in 1917 was 751 tons, valued at $153,204.

The shipments of galena concentrates reported in 1917 were 184 tons, valued at $15,415, compared with 227 tons, valued at $16,868, in 1916. The average lead content was 66.8 per cent, compared with 68 per cent in 1916. The recoverable metallic content of the galena in 1917 was 123 tons, valued at $21,156.

---

[1] Ulrich, E. O., and Smith, W. S. T., The lead, zinc, and fluorspar deposits of western Kentucky: U. S. Geol. Survey Prof. Paper 36, pp. 16–17, 1905.

[2] Fohs, F. J., Fluorspar deposits of Kentucky: Kentucky Geol. Survey Bull. 9, 1907.

The total value of the lead and zinc concentrates shipped from Kentucky mines was $93,783, as against $150,150 in 1916.

The principal sellers of galena concentrates were the Roberts Fluorspar & Lead Co., the Kentucky Fluorspar Co., J. M. Persons, and the Fairview Fluorspar & Lead Co. The galena sold by the Roberts Fluorspar & Lead Co. was obtained from ore mined by means of five shafts, the deepest of which was about 200 feet. The fluorspar jigged yielded less than 1 per cent galena.

The galena shipped by the Kentucky Fluorspar Co. came from various mines operated by the company. The Franklin mine of the Fairview Fluorspar & Lead Co. produced fluorspar ore containing galena from a 300-foot shaft. The galena shipped by J. M. Persons was from the mines of the Ohio Valley Fluorspar Co.

The American Spar Co. operated the Hudson mine of the Eagle Fluorspar Co., near Salem, in Livingston County, and shipped most of the zinc carbonate. The ore was taken from an open cut about 85 feet in depth and treated in two double log washers before shipment.

Zinc carbonate ore was also mined and shipped from the Dearborn and Masser mines by Avery H. Reed. The Pigmy Mining Co. (Inc.) was developing its property near Mexico. There are two shafts each 200 feet deep at this mine, and a 100-ton mill was being erected.

MICHIGAN.

By B. S. Butler.

PRODUCTION.

In 1917 the mines of Michigan produced 255,710,128 pounds of copper, valued at $69,808,865, and 688,551 fine ounces of silver, valued at $567,366, a total value in copper and silver of $70,376,231. This is an increase of $2,576,321 in value over the production of 1916.

The average price of copper per pound for 1917 was $0.273; for 1916 it was $0.246. The average price of silver per fine ounce for 1917 was $0.824; for 1916 it was $0.658. Owing to the increase in the price of copper, there was an increase from $5.45 in 1916 to $5.63 in 1917 in the average value of copper per ton of "rock" treated.

The smelter production or the output of refined copper for 1917 was 268,508,000 pounds, as compared with 269,794,531 pounds in 1916. The difference between the mine and the smelter production is due to the fact that the quantity of "mineral" produced is not the same as the quantity smelted. A company may produce either more or less "mineral" than it smelts during the year.

Production was seriously hampered throughout the year by shortage and inefficiency of labor. There was a considerable extension of power haulage, which aided in relieving the labor situation, but a shortage of labor is likely to continue for the period of the war.

Value of silver and copper produced at Michigan mines in 1916 and 1917.

Year.	Silver.	Copper.		Combined silver and copper.
		Total.	Per ton of "rock."	
1916	$471,549	$67,328,361	$5.45	$67,799,910
1917	567,366	69,808,865	5.63	70,376,231
Increase	95,817	2,480,504	.18	2,576,321

The entire Michigan output of copper and silver is from the Keweenaw district. Both metals occur native in lodes remarkable for their great extent and uniformity. These lodes may be divided into two general classes—the amygdaloid, in which the metals occur together with gangue minerals, such as epidote, calcite, and zeolites, in the cellular portions of lava flows; and the conglomerate, in which the metals and gangue minerals cement and to some extent replace the pebbles forming the conglomerate. Native copper and copper minerals occur in fissures in the district, but the present output from this type of deposit is of little importance. The "rock" [1] is of low grade and requires milling, which produces "mineral" carrying an average of about 65 per cent copper. A small quantity of "barrel" and "mass" copper is sorted at the mines and sent direct to the smelters.

In 1917 there were 12,400,723 short tons of "rock" milled, which yielded 410,262,995 pounds of "mineral" and 255,710,128 pounds of copper.[2]

The average recovery of refined copper per ton of "rock" milled in 1917 was 19.9 pounds, as compared with 21.7 pounds in 1916.

There were 688,551 ounces of silver derived from the electrolytic treatment of 70,329,000 pounds of copper.

Mine production of silver, copper, "mineral," and "rock" in Michigan in 1916 and 1917.

Year.	Silver (fine ounces).	Copper.			"Mineral."		"Rock" (short tons).
		Quantity (pounds).	Yield.		Quantity. (pounds).	Yield (per cent).	
			Pounds per ton of "rock."	Per cent.			
1916	716,640	[a] 273,692,525	21.7	1.08	[b] 436,977,306	62.63	12,364,114
1917	688,551	[a] 255,710,128	19.9	.99	[b] 410,262,995	62.33	12,400,723
Increase or decrease	−28,089	−17,982,297	−1.8	−.09	−26,714,311	−.30	+36,609

[a] Includes copper from sands. [b] Includes "mineral" from sands.

---

[1] Some of the terms used to designate the different materials entering into the mining industry differ for the Lake district from those employed in any other part of the country. Ore is known as "rock," or (if unmined) "copper ground"; the product of concentration is known as "mineral"; and the term "ore" is used to designate the copper minerals (arsenides and sulphides) that occur to a limited extent in the district. Large bodies of native copper are known as "mass" and smaller ones are designated as "barrel work." In this report the local terms will be used, as it does not seem desirable to employ the more usual terms to the exclusion of the local, and a mixture of the two is confusing.

[2] The figures are based on the actual recovery of copper from "mineral" smelted and the estimated recovery from "mineral" that was not smelted during 1916.

Three counties—Houghton, Keweenaw, and Ontonagon—contributed to the output of copper and silver. The following table shows the relative importance of these counties in output of copper and silver for 1916 and 1917:

Mine production of silver and copper in Michigan in 1916 and 1917, by counties.

County.	Silver (fine ounces).	Copper.			"Mineral."		"Rock" (short tons).
		Quantity (pounds).	Yield.		Quantity (pounds).	Yield (per cent).	
			Pounds per ton of "rock."	Per cent.			
1916.							
Houghton	562,295	[a] 213,109,436	22.4	1.12	[b] 346,927,476	61.4	9,266,357
Keweenaw	78,667	48,195,482	20.1	1.00	70,597,440	68.3	2,395,517
Ontonagon	75,678	12,387,607	17.6	.88	19,452,390	63.7	702,240
Total and average	716,640	273,692,525	21.7	1.08	436,977,306	62.6	12,364,114
1917.							
Houghton	558,465	[a] 195,446,231	21.0	1.05	[b] 320,257,671	61.0	9,297,322
Keweenaw	62,581	49,126,614	20.1	1.00	72,839,079	67.4	2,443,551
Ontonagon	67,505	11,137,283	16.9	.84	17,166,245	64.9	659,850
Total and average	688,551	255,710,128	19.9	.99	410,262,995	62.3	12,400,723

[a] Includes copper from sands. [b] Includes "mineral" from sands.

In the following reviews of the operations at the individual mines of the district during 1917, the statements concerning the quantity, character, and tenor of "rock" developed, the quantity of "rock" stamped, the copper recovered per short ton of "rock" stamped, and the cost of production are based on the published reports of the companies. In the few cases in which reports are not published a general statement of the character of operations is made from the best information available.

HOUGHTON COUNTY.

In 1917 the mines of Houghton County produced 195,446,231 pounds of copper and 558,465 ounces of silver. The county occupies the central portion of the copper belt and contains 15 of the 23 mines that produced copper in 1917 and 5 of the 9 mines that produced silver.

"Rock" and "mineral" produced and average yield in silver and copper in Houghton County in 1916 and 1917.

Year.	Silver (fine ounces).	Copper.			"Mineral."		"Rock" (short tons).
		Quantity (pounds).	Yield.		Quantity (pounds).	Yield (per cent).	
			Pounds per ton of "rock."	Per cent.			
1916	562,295	[a] 213,109,436	22.4	1.12	[b] 346,927,476	61.4	9,266,357
1917	558,465	[a] 195,446,231	21.0	1.05	[b] 320,257,671	61.0	9,297,322

[a] Includes copper from sands. [b] Includes "mineral" from sands.

The output of the county shows a decrease of 17,663,205 pounds of copper and of 3,830 fine ounces of silver for 1917.

Calumet & Hecla.—The Calumet & Hecla Mining Co. has been one of the most successful copper-mining companies in the world. To the close of 1917 the company had distributed $145,250,000 in dividends.

The company's ground contains three copper-bearing lodes—the Calumet & Hecla conglomerate, the Osceola amygdaloid, and the "Kearsarge" amygdaloid. A large percentage of the production in the past has come from the conglomerate lode, but with the decrease in copper content of this lode and its approaching exhaustion, the mining from the amygdaloid lodes has increased.

The company's annual report shows the details of operation for 1917 as follows:

During 1917 there were 3,159,570 short tons of "rock" treated, yielding 68,419,826 pounds of copper, or an average of 21.65 pounds of copper per ton of "rock." This compares with a yield of 22.53 pounds for 1916. The total cost per pound of copper was 13.01 cents for 1917, as compared with 11.63 cents for 1916. The recovery of copper from old sands added to the recovery from "rock" made a total production of 77,495,283 pounds.

In 1917 the conglomerate lode produced 1,751,621 tons of "rock," yielding 50,415,860 pounds of copper, or an average of 28.78 pounds per ton of "rock," as compared with 29.97 pounds for 1916.

The Osceola lode has an average width of 30 to 35 feet, though at some points it is much wider. The mineralization is confined principally to the hanging and the foot walls. The lode is opened by drift stopes along the hanging wall, where the mineralization is rather uniform. Crosscuts are extended to the foot wall, where the mineralization is far less regular. During 1917 this lode produced 1,407,949 tons of "rock," yielding 18,003,966 pounds of copper, or 12.79 pounds per ton of "rock." This compares with a yield of 13.6 pounds per ton of "rock" for 1916.

Development on the Kearsarge lode in Calumet & Hecla ground has not been encouraging, though the lode has proved very productive farther north. There was no output from the Kearsarge lode in 1917.

The reclamation plant for treating old tailings from Torch Lake treated 730,543 tons, having an average copper content of 17.06 pounds per ton. A total of 9,075,457 pounds of copper was recovered, or an average of 12.42 pounds per ton, at an average cost, exclusive of smelting and selling, of 5.94 cents per pound.

The regrinding plant treated 512,172 tons of coarse tailings containing 12.74 pounds of copper per ton, making a recovery of 2,222,419 pounds, or 4.34 pounds per ton, at a cost, exclusive of smelting and selling, of 6.48 cents per pound.

The leaching plant treated 643,911 tons of material assaying 0.571 per cent copper, from which 5,250,331 pounds of copper was recovered, or an average of 8.15 pounds per ton, at a cost, exclusive of smelting and selling, of 6.41 cents per pound.

Experimental work with a flotation process for recovering copper from slimes has proven so successful that the company has decided to install this process in the mills.

During the year the Calumet & Hecla Mining Co. acquired all the assets of the Tamarack Mining Co. and the latter company was dissolved.

Tamarack.—The Tamarack Mining Co. was dissolved during the year, its assets having been acquired by the Calumet & Hecla Mining Co. The company had a long and successful career, distributing $9,420,000 in dividends since 1888. In recent years, however, the cost of producing copper from the mine has been high and little profit has resulted since 1907.

Osceola.—In 1917 the Osceola Co. operated the three branches—the Osceola, the South Kearsarge, and the North Kearsarge. Since 1878 this company has distributed dividends to the amount of $16,602,575.

The Osceola branch lies directly south of the Calumet & Hecla and is worked on the Osceola amygdaloid. The property contains the Calumet & Hecla conglomerate lode, but the only portion of it in Osceola ground that has been shown to carry copper in paying quantities was worked out in the early days of the mine.

A total of 203,288 tons of "rock" was produced in 1917, yielding 2,516,736 pounds of copper or an average of 12.38 pounds per ton.

The North Kearsarge lies north of the Wolverine and is worked on the Kearsarge lode. This branch produced 691,263 tons of "rock," yielding 8,667,441 pounds of copper, or an average of 12.54 pounds per ton.

The South Kearsarge lies south of the Wolverine and east of the Centennial on the Kearsarge lode.

This branch produced 343,254 tons of "rock," yielding 4,900,781 pounds of copper, or an average of 14.28 pounds per ton.

In 1917 the company treated 1,237,805 tons of "rock," producing 16,084,958 pounds of copper, an average yield of 13 pounds of refined copper per ton of "rock." This compares with a yield of 15.2 pounds in 1916. The total cost of refined copper per pound was 13.86 cents for 1917 as compared with 11.69 cents in 1916.

Dividends were declared in 1917 to the amount of $1,346,100.

Centennial.—The Centennial ground lies north of the Calumet & Hecla and west of the South Kearsarge and the Wolverine. It contains the Calumet & Hecla, the Osceola, and the Kearsarge lodes, the last being the only one of proved value in the property, and to this lode operations are at present confined.

"Rock" to the amount of 148,332 tons was stamped during the year, producing 2,002,857 pounds of refined copper or 13.50 pounds of refined copper per ton of "rock" stamped. The average cost of refined copper per pound was 18.67 cents, as compared with 13.44 cents for 1916.

Dividends were paid during the year to the amount of $90,000.

Wolverine.—The Wolverine is located between the North Kearsarge and the South Kearsarge branches of the Osceola Co. Its operations are on the "Kearsarge" amygdaloid, though the West lode, parallel with the Kearsarge lode and about 80 feet to the west, has been opened to a small extent. The mine has the distinction of having the richest rock, mined in the district. The operations on the Osceola lode have thus far proved disappointing. The Kearsarge lode in the Wolverine ground shows great uniformity of mineralization and is opened for the full length. In the upper levels the "rock" averaged from 16 to 18 pounds per ton, but as the lower levels were opened it showed marked improvement. As the bottom limits are approached there is a notable decrease in the copper content of the rock.

During the fiscal year ending June 30, 1917, there were stamped 352,845 tons of "rock," which produced 8,753,945 pounds of "mineral," yielding 5,856,889 pounds of copper, or 16.60 pounds of refined copper per ton of "rock" stamped. The total cost per pound of refined copper was 11.62 cents.

Since its organization to June 30, 1917, the company has produced 157,159,999 pounds of copper. Operations have resulted in profits amounting to $10,648,933, of which $9,540,000 has been paid in dividends. Two dividends paid during the fiscal year amounted to $780,000.

Franklin.—The Franklin and the Rhode Island, which is controlled by the Franklin, are located southeast of the La Salle. The property carries several lodes, but in the past exploration has been principally on the "Pewabic" amygdaloid and the Allouez or "Albany and Boston" conglomerate.

The production for the year was mainly from the conglomerate lode, though developments on the amygdaloid lode opened the best ground yet found in that lode.

An output of 303,625 tons of "rock" stamped yielded 3,155,574 pounds of copper.

Quincy.—The Quincy mine is situated just north of the east-west arm of Portage Lake. The property is traversed by most of the lodes of the district, but has derived its principal output in the past from the Pewabic lode,with a small quantity from the West lode.

Dividends to the amount of $1,980,000 were paid in 1917. The total disbursement in dividends from 1862 to 1917 is $25,517,500.

In 1917 there were mined 1,280,837 tons of "rock," which yielded 35,785,490 pounds of "mineral" and 22,195,577 pounds of copper, an average of 17.33 pounds per ton of rock.

Isle Royale.—The Isle Royale mine is situated south of the east-west arm of Portage Lake, near Houghton. The property contains several copper-bearing lodes, of which the Isle Royale is the main producer at present.

During 1917 "rock" amounting to 922,160 tons was treated, yielding 13,480,921 pounds of copper, or an average of 14.6 pounds of copper per ton. The average cost per pound of copper was 15.74 cents as compared with 15.32 cents in 1916.

Dividends were paid to the amount of $600,000.

Baltic, Champion, and Trimountain.—These three mines are located on the Baltic lode southwest of Houghton and are under the management of the Copper Range Consolidated Co. The Baltic is an exceptionally strong lode, having a stoping width varying from 15 to 80 feet. The lode has produced considerable "mass" copper and also contains veinlets of copper minerals, including chalcocite, bornite, and copper arsenides. These minerals are recovered in the mill, and the arsenides probably account in part for the arsenical character of the Copper Range output.

During 1917 a total of 325,342 tons of "rock" from the Baltic mine was stamped, producing 11,214,861 pounds of refined copper, or 34.47 pounds of refined copper per ton of "rock" stamped. The cost per pound of refined copper was 13.769 cents.

A total of 264,655 tons of "rock" from the Trimountain was stamped, yielding 6,278,097 pounds of refined copper, or an average of 23.72 pounds per ton. The average cost per pound of copper was 15.223 cents.

Since its organization the company has produced 116,808,125 pounds of copper at a profit of $4,790,329, of which $1,450,000 has been disbursed as dividends.

The Champion Copper Co. is controlled jointly by the Copper Range Consolidated Co. and the St. Mary's Mineral Land Co. A total of 776,036 tons of "rock" was stamped, yielding 27,550,343 pounds of refined copper, a yield of 35.50 pounds per ton of "rock" stamped. The cost of refined copper per pound was 10.404 cents.

From its organization to the close of 1917 the Champion Co. has produced 286,423,553 pounds of copper at a profit of $24,236,646, of which $21,994,540 has been disbursed as dividends.

Superior.—During the year 129,587 tons of "rock" from the Superior was stamped, producing 2,201,672 pounds of copper, or 16.99 pounds per ton of "rock" stamped. The cost of copper a pound was 16.88 cents. The second dividend of $100,000 was paid in 1917.

La Salle.—The La Salle Co. produced 185,014 tons of "rock," yielding 1,919,775 pounds of copper, or an average of 10.38 pounds per ton of "rock." The net cost per pound of copper was 10.38 cents.

Winona.—The Winona produced 112,082 tons of "rock," which yielded 2,640,780 pounds of "mineral" and 1,494,472 pounds of refined copper, an average of 13.33 pounds of refined copper per ton of "rock" stamped.

The production from the mine after October 1 was by tributers.

Hancock.—The Hancock Consolidated Mining Co. treated 302,725 tons of "rock," which yielded 4,005,882 pounds of refined copper, an average of 13.223 pounds per ton.

New Arcadia.—The new Arcadia Copper Co. shipped 4,900 tons of "rock," yielding 53,278 pounds of refined copper.

Houghton.—The Houghton Copper Co. produced 15,628 tons of rock, yielding 291,500 tons of mineral and 179,012 pounds of copper, or an average of 11.45 pounds per ton.

Other companies.—Other companies were active in development work.

KEWEENAW COUNTY.

In 1917 Keweenaw County produced 49,126,614 pounds of copper and 62,581 fine ounces of silver. The county occupies the northern portion of the copper belt.

"Rock" and "mineral" produced and average yield in silver and copper in Keweenaw County in 1916 and 1917.

Year.	Silver (fine ounces).	Copper.			"Mineral."		"Rock" (short tons).
		Quantity (pounds).	Yield.		Quantity (pounds).	Yield (per cent).	
			Pounds per ton of "rock."	Per cent.			
1916	78,667	48,195,482	20.1	1.00	70,597,440	68.3	2,395,517
1917	62,581	49,126,614	20.1	1.00	72,839,079	67.4	2,443,551

Ahmeek.—The Ahmeek mine, lying north and east of the Allouez, is located on the Kearsage lode.

A total of 1,271,275 tons of "rock" were stamped, yielding 27,919,812 pounds of refined copper, or 22 pounds of refined copper per ton of "rock." The total cost per pound of refined copper was 9.42 cents. During the year dividends were declared to the amount of $2,800,000. Total dividends to the close of 1917 amounted to $9,650,000.

Allouez.—The Allouez mine is north of the North Kearsarge, and in 1917, as in recent years, operations were confined to the Kearsarge lode. As this lode does not outcrop on Allouez property the shafts were started in the hanging wall at a steep angle and flattened to the dip of the copper-bearing bed just before reaching it. This plan avoids the expense of long crosscuts necessitated by vertical shafts.

A total of 566,674 tons of "rock" was stamped during 1917, yielding 8,892,915 pounds of refined copper, an average of 15.69 pounds of refined copper per ton of "rock." The total cost per pound of refined copper was 13.84 cents.

Dividends declared during the year amounted to $1,050,000. Total dividends to April, 1918, amounted to $2, 300, 000.

Mohawk.—The Mohawk mine, lying east of the Ahmeek, carries the outcrop of the Kearsarge lode for more than a mile and also contains several cross fissures carrying arsenides of copper, which have been mined to a considerable extent in the past.

A total of 605,202 tons of "rock" were stamped, yielding 17,775,200 pounds of "mineral," and 12,313,887 pounds of copper, or an average of 20.35 pounds per ton of "rock." The total cost per pound of refined copper was 11.32 cents.

Since organization the Mohawk Co. has produced 159,454,802 pounds of copper, at a profit of $9,880,440, of which amount $7,625,000 has been disbursed as dividends.

Keweenaw.—The Keweenaw Copper Co. treated 41,148 tons of "rock," yielding 619,413 pounds of "mineral" and 380,536 pounds of copper or 9.248 pounds per ton of "rock."

ONTONAGON COUNTY.

In 1917, Ontonagon County produced 11,137,283 pounds of copper. Ontonagon County contains the southwestern portion of the copper belt. This portion has not been so thoroughly developed as the others and consequently the geology is less understood than in the more northern counties. So far as developed, the lodes are more "bunchy" than to the north and have produced a relatively high percentage of mass copper. The production of 1917 was derived wholly from amygdaloid rock.

"Rock" and "mineral" produced and average yield in silver and copper in Ontonagon County in 1916 and 1917.

Year.	Silver (fine ounces).	Copper.			"Mineral."		"Rock" (short tons).
		Quantity (pounds).	Yield.		Quantity (pounds).	Yield (per cent).	
			Pounds per ton of "rock."	Per cent.			
1916	75,678	12,387,607	17.6	0.88	19,452,390	63.7	702,240
1917	67,505	11,137,283	16.9	.84	17,166,245	64.9	659,850

Mass.—The Mass mine adjoining the Adventure on the southwest, carries six known copper-bearing amygdaloid lodes—the Knowlton, the Mass, the North Butler, the Butler, the Ogima, and the Evergreen. In addition, the position of the property makes it probable that the newly discovered lodes in this part of the district may be present in Mass ground. The main developments for the year were from "B" and "C" shafts on the Butler and Evergreen lodes and continued to show as satisfactory conditions with respect to copper values as in previous years.

A total of 244,671 tons of "rock" was stamped in 1917, yielding 6,082,820 pounds of "mineral" and 3,984,616 pounds of refined copper, an avernge of 16.29 pounds of refined copper per ton of "rock" stamped. The average cost per pound of refined copper was 19.81 cents.

Victoria.—The Victoria is the most southwesterly of the Lake mines that have made important production. The present production is from the Forest lode. "Rock" amounting to 137,286 tons was stamped, yielding 2,631,693 pounds of "mineral" and 1,612,640 pounds of copper.

White Pine.—The White Pine Copper Co. treated 212,889 tons of "rock," yielding 4,067,529 pounds of copper at a cost per pound of 14.99 cents per pound.

The Lake mine was a producer in 1917.

The Michigan Copper Co. produced 2,091 tons of "rock," which with "mass" and "barrel" copper yielded 35,400 pounds of copper.

The Adventure Consolidated Copper Co. operated until late in October, when it was closed. Sales of 652,977 pounds of copper yielded $198,562.

The South Lake Mining Co. shipped during the year. Shipments from May, 1916, to December 31, 1917, amounted to 68,388 tons of "rock" which produced 754,433 pounds of refined copper, or 11.03 pounds per ton.

The Wyandotte Copper Co. made two test shipments of "rock," which were treated at the Winona mill, and gave encouraging results.

Other companies were active in exploration and development.

MISSOURI.

By J. P. Dunlop.

PRODUCTION.

VALUE.

The value of the mine production of recoverable silver, copper, lead, and zinc in Missouri in 1917 was $67,540,500, compared with $74,143,607 in 1916. The value of the copper production showed an increase of $4,645 and that of lead increased $8,108,688. The value of the silver decreased $34,431 and that of zinc decreased $14,682,008, so that the large decrease in the total value was caused almost entirely by the lower average price of zinc in 1917, compared with 1916. The recoverable lead content of Missouri lead concentrates sold in 1917 was equal to 36.6 per cent of the smelter production of primary lead in the United States derived from domestic ores, and the recoverable spelter content from Missouri zinc concentrates sold in 1917 was 22.7 per cent of the primary spelter produced by smelters from domestic ores in 1917.

Mine production of silver and copper in Missouri, 1910–1917.

Year.	Copper.		Silver.		Lead concentrates, silver bearing (short tons).
	Quantity (pounds).	Value.	Quantity (fine ounces).	Value.	
1910	94,452	$11,955	33,096	$17,872	35,002
1911	640,411	80,051	49,867	26,430	51,109
1912	440,725	72,719	35,438	21,794	31,183
1913	576,204	89,312	35,620	21,514	35,854
1914	44,463	5,914	61,168	33,826	61,995
1915	492,160	70,378	57,756	29,282	64,377
1916	386,200	95,005	129,450	85,178	88,081
1917	365,013	99,649	61,586	50,747	76,222

For several years prior to 1913 the entire production of silver in Missouri had been derived from refining lead concentrates, but in each of the last five years a small quantity of silver has been obtained from oxidized copper ore shipped from mines in Ste. Genevieve, Washington, and other counties. The quantities given in the fourth column of the foregoing table are those of recovered silver. The silver content of the lead ores is so small that it is disregarded in the assay and sale of the concentrates. For this reason the smelter reports must be relied on for the silver production. As may be seen by inspection of the table, the quantity of silver produced in any year bears no direct ratio to the quantity of lead concentrates smelted during that year. The reason for this is that the silver content is so small in quantity that the silver bullion is stored and refined in batches. If a series of years be taken into account, the concentrates are seen to average less than 1 ounce of silver to the ton.

The production of copper in Missouri in 1917 was 365,013 pounds, valued at $99,649, as compared with 386,200 pounds, valued at $95,005, in 1916. The North American mine now owned by the Missouri Cobalt Co., which produced some copper as well as nickel and cobalt in the years 1908 and 1909, marketed no copper in 1917, although some ore was mined. Nearly all the copper output for 1917 was derived from concentrates recovered in dressing lead ore mined in St. Francois County, in southeastern Missouri. Some copper ore was mined and shipped from the Racola mine in Washington County. In addition to the copper the ore is reported to have yielded some silver.

LEAD AND ZINC.

The total value of the recoverable metallic content of the lead and zinc concentrates produced in Missouri in 1917 was $67,390,104, a decrease of $6,573,320 from that of 1916. The production of lead concentrates in Missouri in 1917 (of which all but 394 tons was galena) was 345,513 short tons, valued at $34,038,976, as compared with an output of 347,869 tons, valued at $24,172,965, in 1916, a decrease of 2,356 tons in quantity but an increase of $9,866,011 in value. Of this production in 1917 of lead concentrates 306,473 tons, valued at $30,070,995, was derived from southeastern and central Missouri, a decrease of 552 tons in quantity and an increase of $9,350,258 in value. The average metal content of the lead concentrates from these districts was 66.7 per cent, as compared with 65.66 per cent in 1916, and the value per ton in 1917 was $98.01. The quantity of recoverable lead in southeastern and central Missouri concentrates in 1917 amounted to 204,545 tons, an increase of 2,913 tons. The output was equal to about 32 per cent of the primary lead smelted or refined from domestic ores in the United States in 1917.

Shipments of lead concentrates from southwestern Missouri were 39,040 tons, valued at $3,967,981, as compared with 40,844 tons, valued at $3,452,228, in 1916. The lead carbonate concentrates amounted to 394 tons, valued at $30,087, an increase of 367 tons. The quantity of recoverable lead from southwestern Missouri, or the Joplin region, was 29,611 tons, valued at $5,093,092, a decrease of 1,845 tons. The average metal content of the galena concentrates from southwestern Missouri was 76 per cent and the average price per ton was $101.90, or $17.36 more per ton than in 1916.

The quantity of zinc blende concentrates sold from Missouri mines in 1917 was 231,588 tons, valued at $16,453,629, a decrease of 45,588 tons in quantity and of $6,424,586 in value, when compared with the figures for 1916. All the blende concentrate except 186 tons was produced in southwestern Missouri. The average price received per ton was $71.04 and the average recoverable zinc content reported by the sellers was 58.5 per cent. The average price paid per ton in 1916 was $82.55 and the average recoverable zinc content was 58.7 per cent.

The zinc content of the sphalerite concentrates derived from "sheet ground" mines, which was 58.6 per cent in the years 1911 and 1912, declined to 58.3 per cent in 1913, increased to 58.4 per cent in 1914, to 59.1 per cent in 1915, and to 59.2 per cent in 1916, and decreased to 58.6 per cent in 1917. The average price received for all sphalerite concentrates in 1917 was $11.51 a ton less than in 1916.

The zinc carbonate and silicate concentrates sold in 1917 amounted to 30,986 tons, valued at $1,254,975. This was 4,092 tons more in quantity and $95,406 less in value than the sales in 1916. The output in 1917 was mainly from southwestern Missouri, the shipments from southeastern and central Missouri being only 293 tons, valued at $7,145, as compared with 1,030 tons, valued at $42,129, in 1916. The average metal content of the zinc carbonate and silicate concentrates was 39.7 per cent in 1917. The average value per ton in 1916 was $40.50 as compared with $50.21 in 1916.

The combined value of lead and zinc concentrates from southeastern and central Missouri in 1917 (which produced about 89 per cent of the lead concentrates) was $30,094,484, or $9,317,218 more than in 1916.

The total value of the southwestern Missouri lead and zinc concentrates was $21,653,096, as compared with $27,624,295 in 1916, a decrease of $5,971,199.

The total quantity of crude ore or "dirt" mined and treated in 1917 amounted to 17,024,000 short tons, a decrease of about 1,640,000 tons, or approximately 9 per cent less than the quantity mined and treated in 1916. As the total amount received for all classes of lead and zinc concentrates sold in 1916 was $51,747,580 the average value per ton of crude ore or "dirt" mined and treated was $3.04, as compared with $2.60 in 1916, with $2.20 in 1915, $1.65 in 1914, $1.72 in 1913, and $1.86 in 1912. The increase of 44 cents a ton was entirely from the lead ores mined in southeastern Missouri.

The small quantity of copper ore mined and shipped in 1917 is excluded from these calculations.

In the following tables showing the tenor of crude ore ("dirt") and concentrates from Missouri it has been considered advisable to segregate the ores of different nature. For instance, the disseminated lead ore of southeastern Missouri differs radically from the lead and zinc ores of the so-called "soft ground" deposits of southwestern Missouri, and these in turn differ from the "sheet ground" deposits of the same region. Each class of ore has its peculiar problems of mining and ore dressing. This fact makes desirable the separate treatment of the statistical data. In general, the tables reflect very closely the conditions of the industry.

Production of lead and zinc in Missouri in 1917.

District.	Lead concentrates.			
	Galena.		Carbonate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Southwestern Missouri:				
Alba-Neck City	389	$39,593		
Ash Grove-Everton	8	800		
Aurora	229	21,337	25	$1,189
Carl Junction				
Carthage	93	9,996		
Cave Springs	209	22,450		
Diamond		9		
Duenweg-Porto Rico	6,010	602,569	354	28,129
Fairview and Pioneer	5	500		
Granby	540	47,611		
Joplin	7,072	704,389	7	387
McDowell-Stark City	5	400		
Oronogo	2,331	228,801		
Sarcoxie-Reeds				
Sherwood-Thoms station	271	27,761		
Spring City-Beef Branch	387	42,113	3	107
Springfield	172	10,579		
Spurgeon-Seneca	138	13,287	5	275
Stott City				
Webb City-Carterville-Prosperity	20,650	2,143,772		
Wentworth	10	1,100		
Zincite-Klondike	77	6,522		
Christian County	49	5 233		
Ozark, Howell, Wright, and Taney counties	1	72		
	38,646	3,937,894	304	30,087
Central and southeastern Missouri	306,473	30,070,995		
State total, 1917	345,119	34,008,889	394	30,087
1916	347,842	24,171,305	27	1,660

District.	Zinc concentrates.			
	Sphalerite.		Silicate and carbonate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Southwestern Missouri:				
Alba-Neck City	9,001	$607,099	474	$17,486
Ash Grove-Everton	....	....	1,719	52,367
Aurora	3,123	209,749	4,717	176,102
Carl Junction	320	24,553	....	....
Carthage	4,827	333,742	5	97
Cave Springs	1,603	123,661	....	....
Diamond	798	62,630	98	4,731
Duenweg-Porto Rico	38,093	2,628,085	3,057	150,149
Fairview and Pioneer	....	....	50	1,850
Granby	6,126	413,491	15,828	656,561
Joplin	52,525	3,620,420	1,532	67,356
McDowell-Stark City	....	....	30	1,022
Oronogo	9,918	642,602	....	....
Sarcoxie-Reeds	1,542	109,212	....	....
Sherwood-Thoms station	1,465	102,641	65	2,850
Spring City-Beef Branch	294	20,434	1,379	56,589
Springfield	1,583	118,478	....	....
Spurgeon-Seneca	2,702	161,038	419	17,063
Stott City	604	45,465	....	....
Webb City-Carterville-Prosperity	86,415	6,230,272	....	....
Wentworth	6,250	380,088	293	10,894
Zincite-Klondike	4,154	300,321	....	....
Christian County	52	2,578	520	20,289
Ozark, Howell, Wright, and Taney counties	7	417	507	12,424
	231,402	16,437,285	30,693	1,247,830
Central and southeastern Missouri	186	16,344	293	7,145
State total, 1917	231,588	16,453,629	30,986	1,254,975
1916	277,176	22,878,215	26,894	1,350,381

District.	Metal content.[a]			
	Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Southwestern Missouri:				
Alba-Neck City	306	$52,632	4,889	$997,356
Ash Grove-Everton	6	1,032	571	116,484
Aurora	191	32,852	3,290	671,160
Carl Junction	....	....	173	35,292
Carthage	74	12,728	2,609	532,236
Cave Springs	165	28,380	844	172,176
Diamond	....	....	467	95,268
Duenweg-Porto Rico	4,779	821,988	21,181	4,320,924
Fairview and Pioneer	4	688	17	3,468
Granby	387	66,564	8,855	1,806,420
Joplin	5,402	929,144	28,568	5,827,872
McDowell-Stark City	4	688	11	2,244
Oronogo	1,760	302,720	5,313	1,083,852
Sarcoxie-Reeds	....	....	869	177,276
Sherwood-Thoms station	216	37,152	779	158,916
Spring City-Beef Branch	309	53,148	649	132,396
Springfield	137	23,564	874	178,296
Spurgeon-Seneca	106	18,232	1,522	310,488
Stott City	....	....	337	68,748
Webb City-Carterville-Prosperity	15,659	2,693,348	45,103	9,201,012
Wentworth	8	1,376	3,200	652,800
Zincite-Klondike	59	10,148	2,238	456,552
Christian County	38	6,536	214	43,656
Ozark, Howell, Wright, and Taney counties	1	172	157	32,028
	29,611	5,093,092	132,730	27,076,920
Central and southeastern Missouri	204,545	35,181,740	188	38,352
State total, 1917	234,156	40,274,832	132,918	27,115,272
1916	233,088	32,166,144	155,960	41,797,280

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses in zinc but not in lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average sales price (all grades) and the value of the zinc from the average sales price of all grades reported by smelters.

Tenor of crude lead and zinc ore and concentrates produced in southwestern Missouri in 1916 and 1917.[a]

	1916	1917
SOFT GROUND.		
Total crude ore....short tons..	4,711,700	3,447,850
Total concentrates in crude ore....per cent..	3.38	4.04
Lead....do....	.28	.33
Zinc....do....	3.10	3.71
Metal content of crude ore....do....	1.92	2.24
Lead....do....	.22	.25
Zinc....do....	1.70	1.99
Average lead content of galena concentrates....do....	78.0	76.1
Average lead content of lead carbonate concentrates....do....	55.5	62.2
Average zinc content of sphalerite concentrates....do....	58.1	58.3
Average zinc content of silicates and carbonates....do....	39.4	39.7
Average value per ton:		
Galena concentrates....	$82.09	$97.94
Lead carbonate concentrates....	$61.48	$76.36
Sphalerite concentrates....	$77.94	$69.50
Zinc silicates and carbonates....	$50.21	$40.50
SHEET GROUND.		
Total crude ore....short tons..	8,484,700	7,688.250
Total concentrates in crude ore....per cent..	2.19	2.11
Lead....do....	.33	.36
Zinc....do....	1.86	1.75
Metal content of crude ore....do....	1.35	1.31
Lead....do....	.25	.28
Zinc....do....	1.10	1.03
Average lead content of galena concentrates....do....	76.5	75.9
Average content of sphalerite concentrates....do....	59.2	58.6
Average value per ton:		
Galena concentrates....	$85.62	$103.51
Sphalerite concentrates....	$86.02	$72.16

[a] Including also the small production of lead and zinc ores in southeastern and central Missouri.

Tenor of crude lead ore and concentrates in southeastern Missouri disseminated lead ore in 1916 and 1917.

	1916	1917
Total crude lead ore....short tons..	5,467,500	5,887,900
Galena concentrates in crude ore....per cent..	5.60	5.03
Lead content in crude ore....do....	3.68	3.47
Average lead content of galena concentrates....do....	65.66	66.7
Average value per ton of galena concentrates....	$67.47	$98.01

In Mineral Resources for 1914, Part I, pages 72–77 and 97–100, was given a brief history of lead and zinc mining in the southeastern Missouri and Joplin regions, together with data relating to the total lead and zinc production, the mining and milling practice, and the methods of selling ore and concentrates. The separate chapter entitled "Silver, copper, lead, and zinc in the Central States in 1914" is available for distribution and can be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

In order to expedite the prompt publication and distribution of this report much of the data relating to individual properties as given in previous reports under the reviews by districts has been omitted. All the essential data relating to the districts are included in the yearly State review of the regions.

SOUTHWESTERN MISSOURI.

AREA, ORES, DEPOSITS.

The southwestern Missouri lead and zinc areas includes the largest part of the Joplin region, the remaining portion lying in southeastern Kansas and in northeastern Oklahoma. The Missouri part of the region was first developed, then that in Kansas, followed at a considerably later period by that in Oklahoma.

The ore in southwestern Missouri occurs in the Mississippian Boone limestone, in beds of Kinderhook age. The ore deposits are found in Jasper, Newton, Lawrence, Greene, and adjoining counties. This area produced in 1917 only 56 per cent of the lead and zinc ore mined in the Joplin region, compared with 78 per cent in 1916.

The lead ores are galena, with a small quantity of lead carbonate, locally known as "dry bone." The zinc ores are sphalerite or zinc blende, or "jack," zinc carbonate (smithsonite), and zinc silicate (calamine), both of the latter locally called "silicate." The galena contains but a small fraction of an ounce of silver to the ton of lead concentrates, and although ordinarily it is not desilverized, yet occasionally the refineries find it advantageous to add lead from the Joplin region to their charges, without, however, making any record of the silver content. In this way an unknown but small quantity of silver is recovered from southwestern Missouri lead ore. The zinc ores, sphalerite, smithsonite, and calamine, contain notable quantities of cadmium. being fully as rich in this respect as the zinc ores of Silesia, which are the source of the cadmium production of Europe. Discussion of the cadmium content of these ores is taken up in the chapters entitled "Cadmium," in Mineral Resources for 1908 and for 1917.

The ore deposits of the Joplin district vary in character with the depth of mining. The shallower ores beginning at the surface are universally pockety and are found in residual clays or in "runs" in the basal breccias of the region. The breccias and the forms of the "runs" are largely, if not altogether, due to solution of the limestone strata. One form of run, which is fairly numerous, is the "circle" deposit, which, in the popular view, has come to be nearly synonymous with rich deposits. Small veins, vertical sheets, and thin crevice deposits are often met with in prospecting, but unless they develop into stringers leading into paying ore bodies are forgotten in the multitude of rich pockety deposits which the district has yielded. The blanket deposits or "sheet ground" are found in the Grand Falls chert member of the Boone limestone at depths varying from 100 to 275 feet, according to the topography and the geologic structure. Below this horizon there are, in the beds of Kinderhook age, deposits of disseminated ore. They have been found in prospect shafts or drill holes near Springfield, Aurora, Granby, Carterville, Joplin, Hornet, and Cave Springs, in Missouri; at Galena, in Kansas; and at Quapaw, in Oklahoma.

Lead and zinc concentrates produced in the Missouri part of the Joplin region, 1907–1917.

	Quantity (short tons).	Value.
Lead concentrates	407,556	$25,189,452
Sphalerite concentrates	2,509,336	130,027,468
Zinc carbonate and silicate concentrates	249,689	7,757,329
	3,166,581	162,974,249

The average price per ton received for sphalerite concentrates during the period 1907 to 1917 was $51.82, and that for zinc silicate and carbonate was $31.07.

ASSAYS.

Several of the assayers in the Joplin district make a practice of saving the remnants of blende samples analyzed during the year. At the close of the year the lot is thoroughly mixed and carefully sampled, from which sample an average or composite assay for the year is made. Each assay thus represents several thousand lots. Two representative series of such composite assays are given below. In most cases each sample included in the composite assay represents a carload lot of concentrates.

The first series, by W. W. Petraeus and Evans W. Buskett, of Joplin, gives the result of analyses of composite samples from the general district for the last 16 years. The analyses for 1897–1905, inclusive, were published in the Lead and Zinc News, volume 9, page 8, January 15, 1906. The analyses for 1906–1913 were kindly communicated by Mr. Petraeus and those for 1914–1917 by Mr. Buskett. Iron was not taken into account until 1900. Some 400 scattering assays, made in 1895–96, are excluded from the table.

Composite assays of zinc blende from the Joplin region, 1897–1917.

[W. W. Petraeus, analyst, 1897–1913; Evans W. Buskett, analyst, 1914–1917.]

Year.	Number of lots in the composite.	Percentage.				
		Zinc.	Iron.	Lead.	Copper.	Cadmium.
1897	600	56.64				
1898	1,299	56.99				
1899	3,715	56.67				
1900	3,500	57.36	0.22			
1901	3,683	57.53	2.02			
1902	5,776	57.08	2.24			
1903	6,014	57.30	2.00			
1904	6,220	57.24	2.10			
1905	4,628	57.97	1.84	1.00	0.001	0.198
1906	5,644	57.2	2.00			
1907	6,813	56.8	1.93			
1908	7,837	56.4	1.76			
1909	9,002	56.3	2.00			
1910	8,892	56.6	2.10	1.02	.06	.399
1911	8,920	57.1	2.40			
1912	9,474	57.7	2.40			
1913	7,010	57.1	2.40			
1914	420	56.40	2.70			
1915	1,806	56.76	2.36			
1916	2,190	57.0	2.30	.54		
1917	[a]3,000	57.3	2.25	.52		

[a] Estimate.

The next series of composite assays was communicated by Prof. W. George Waring and Bruce Williams, of Webb City. The original samples were of ores from the different camps of the district except where otherwise indicated. The methods used in making these assays have been published.[1]

Composite assays of zinc blende from the Joplin region, 1900–1917.

[W. George Waring and Bruce Williams, analysts.]

Year	Number of lots in the composite.	Percentage.				
		Zinc.	Iron.	Lead.	Cadmium.	Copper.
1900	3,894	57.30	3.03	....	....	....
1901	5,172	56.60	3.30	....	....	....
1901	2,577	55.30	3.86	....	....	....
1901	[a] ±2,000	55.90	3.47	....	....	....
1902	2,270	57.08	2.65	0.904	0.337	0.050
1903	2,145	57.75	2.32	1.072	.388	.049
1904	[a] 3,800	58.26	2.23	.701	.304	.049
1904	[b] 2,691	58.46	1.97	.720	.430	.050
1904	1,984	58.95	2.10	....	....	....
1905	4,520	58.95	2.00	....	....	....
1906	4,638	58.40	2.20	....	....	....
1906	3,968	58.20	2.29	....	....	....
1907–8	±4,000	58.70	2.00	....	....	....
1909	....	[c] 57.40	2.60	....	....	....
1910	6,377	[c] 57.90	2.60	....	....	....
1911	5,653	58.20	2.35	.856	.450	.034
1912	6,709	56.72	2.50	1.070	.256	.022
1913	7,364	56.82	2.81	1.112	.209	.036
1914	7,931	56.56	2.80	1.30	.287	.038
1915	9,240	57.19	2.40	.935	....	....
1916	10,451	57.95	2.20	.720	.262	.054
1917	10,041	58.10	2.65	.630	.324	.046

[a] Joplin. [b] Webb City. [c] The composite sample included some lots of silicate ores.

The complete analysis of the composite sample of the 3,800 lots of concentrate from the Joplin region in 1904, sampled by C. V. Millar and analyzed by Waring, is as follows:

Analysis of composite sample of zinc blende from the Joplin region.

Zinc	58.26	Calcium carbonate	1.88
Cadmium	.304	Magnesium carbonate	.85
Lead	.70	Barium sulphate	.82
Iron	2.23	Silica	3.95
Manganese	.01		
Copper	.049		99.773
Sulphur	30.72		

Analysis of a representative sample of sphalerite jig concentrates from "sheet-gronnd ore" from the Cartersville, Mo., area.

[Waring & Williams Laboratories, Webb City, Mo., analyst.]

Zinc	59.20	Germanium, gallium, and indium (spectroscopic determination)	Traces.
Cadmium	.058	Calcium carbonate	Traces.
Lead	.293	Silica (possibly including traces of barium sulphate)	6.971
Iron	1.900		
Copper	.054		99.777
Sulphur	31.301		
Manganese			
Nickel and cobalt	Traces.		

---

[1] Waring, W. G., The volumetric determination of zinc: Am. Chem. Soc. Jour., vol. 26, No. 1, January, 1904. In addition to the composite assays for 1902 and 1903, shown in the table, the article gives the lead, copper, and cadmium content of a number of ores from individual mines in Missouri, Kentucky, and Illinois.

The year 1917 proved very unsatisfactory to operators of zinc mines in southwestern Missouri. There was no reduction in the high cost of operating as set forth in detail in this report for 1916, and the selling price of sphalerite was in many cases below the cost of production after May, 1917. Development in the "sheet ground" areas ceased entirely. Many of the mills were closed, as it was not possible to operate profitably many mines where the dirt ran from 2 to 2.75 per cent in concentrates. In many cases the mills were moved to mines in the Miami district. On account of the scarcity of mill material and the delays in shipping it was possible to obtain prices for second-hand milling and mining equipment very much in excess of the ordinary prices. There were very few transfers of mining property in the old camps in southwestern Missouri and few new concentrating plants were built. In outlying camps considerable drilling and development was done and some mills were built. The production of zinc carbonate and silicate, mainly by small operators, increased about 4,800 tons, although the output of sphalerite decreased more than 45,000 tons. Efforts were made to fix a price for prime western spelter which would enable most of the mines to obtain a price for medium and low-grade sphalerite concentrates which would make operating profitable, but the efforts were without result. In May, 1918, the producers of high-grade sphalerite that contained little or no lead made an arrangement by which certain smelters producing high-grade spelter agreed to purchase a limited quantity of sphalerite at $75 a ton. This tonnage was allocated to the various producers of high-grade sphalerite. As this production is in excess of the smelter requirements, the anomaly is presented of part of the production of a mine selling at $75 a ton and the remainder for as little as $55 to $60 a ton.

The quantity of sphalerite concentrates at the mines was negligible at the beginning of 1917, but the stocks increased during the last months of the year, and in addition to the quantity unsold there were several thousand tons sold but not shipped on account of scarcity of cars and the delay caused by an unusually heavy snowstorm in December. The quantity of concentrates on hand, sold and unsold, at the end of 1917 was estimated at between 25,000 and 30,000 tons. Stocks of galena concentrates, which were very small at the beginning of 1917, were also larger at the end of 1917, though there was very little galena at Missouri mines other than that which was sold but not shipped.

As indicated by the total production for 1917, the average weekly output of concentrates from mines in southwestern Missouri was 4,450 tons of sphalerite, 570 tons of zinc carbonate and silicate, and 580 tons of galena. In December many of the mines had been closed down entirely or were operating single shift, and the weekly shipment of sphalerite was less than 2,500 tons.

As in 1916, the conspicuous feature of the ore market was the great difference between the base prices offered for sphalerite. There was usually a difference of at least $10 a ton, and occasionally as much as $20 a ton, between the base price offered for lead-free or nearly lead-free sphalerite and the medium and low-grade sphalerite concentrates containing above 0.5 per cent of lead. The average quoted base prices for 60 per cent sphalerite were highest in February, when a small quantity of concentrates sold for about $100 a ton.

In the first week in January the base prices quoted were from $74 to $83 a ton. Base prices for the lower grades advanced to $80, and for high grades to $90 in the last half of February and in March. In April base prices declined to $65 and $70 for low-grade concentrates and to $75 to $80 for high grade. In July, August, and September the prevailing quotations ranged from $65 to $75. The October base price for low-grade concentrates declined $5. Prices then gradually declined during November and December, when the base prices reached $50 for low-grade concentrates and $70 for high-grade concentrates. The actual average selling price of all concentrates was about $30 a ton less in December than in February.

Base prices for calamine or zinc silicate ores followed the sphalerite quotations. The lowest base prices were in November and December, when they ranged from $30 to $35 a ton, and the highest were in February, when they ranged from $50 to $55 a ton.

The quoted price for 80 per cent galena showed wide variations, opening in January at $90 a ton and closing in December at $70 to $75 a ton. During the year galena sold for as much as $135.50 a ton in April and August and for as little as $64 at the end of November. The high prices did not stimulate the production of lead from southwestern Missouri, for there was a slight decrease in production. There will be a further decrease in 1918, owing to the closing of most of the mines working "sheet ground."

The average price per ton paid for sphalerite or blende in 1917 was $71.04, as compared with $82.60 in 1916, $76.25 in 1915, $38.74 in 1914, $40.70 in 1913, and $50.44 in 1912; and for zinc silicate or carbonate concentrates it was $40.50 in 1917, $50.21 in 1916, $45 in 1915, $21.13 in 1914, $22.45 in 1913, and $28.95 in 1912. The average price paid for galena concentrates was $101.90 in 1917, as compared with $84.29 in 1916, $52.52 in 1915, $46.83 in 1914, $51.50 in 1913, $55.36 in 1912, and $55.75 in 1911. These prices are not average base price quotations but are the actual average prices calculated from the quantity sold and the values reported to the United States Geological Survey by the sellers.

The prices received by the producers show that the average actual selling price of sphalerite in 1917 was $11.56 a ton less than in 1916, a decrease of 14 per cent, and that the corresponding decrease in prices for zinc carbonate and silicate in 1917 was $9.71, a larger percentage of decrease than in the price of sphalerite.

The average metal content of sphalerite concentrates derived from "soft ground" increased from 58.1 per cent in 1916 to 58.3 per cent in 1917, and the content of those derived from "sheet ground" decreased from 59.2 per cent in 1916 to 58.6 per cent in 1917. The average metal content of the galena concentrates derived from "soft ground" was 1.9 per cent less than in 1916. The average metal content of the galena derived from "sheet ground" was 0.6 per cent less than in 1916.

The recovery of sphalerite and galena concentrates from "sheet ground" declined from 2.19 per cent in 1916 to 2.11 per cent in 1917. The decrease was entirely in the sphalerite concentrates and the large increase in the price paid for galena aided the operators of "sheet ground." Many continued to operate their "sheet ground," hoping for an advance in the price of sphalerite, which did not materialize.

The average recovery of concentrates from "soft ground" increased from 3.38 per cent in 1916 to 4.04 per cent in 1917. This was due to the larger quantity of zinc silicate ore mined and to the shutting down of a great many of the larger mines.

The total ore or "dirt" treated decreased from 13,196,400 tons in 1916 to 11,136,100 tons in 1917. The "dirt" treated from "sheet ground" was 7,688,250 tons, a decrease of about 796,000 tons, and that from "soft ground" was 3,447,850 tons, a decrease of about 1,264,000 tons.

In 1917 the sphalerite concentrates derived from "sheet ground" mines amounted to 134,778 tons and the galena concentrates to 28,159 tons. In 1917 "soft ground" mines yielded 96,810 tons of sphalerite, 10,889 tons of galena, and all of the lead carbonate, zinc silicate, and zinc carbonate concentrates. The production of sphalerite concentrates from "sheet ground" decreased 23,026 tons, and that of galena increased 82 tons. The decrease of sphalerite from "soft ground" was 22,562 tons and that of galena 2,374 tons, though the quantity of zinc carbonate and silicate increased 4,092 tons.

The total value of all concentrates derived from "sheet ground" mines was $12,639,983, and from "soft ground" mines $9,080,080. This shows that the value of the production of concentrates from "soft ground" in 1917 amounted to $3,559,903 less than the production from "sheet ground," whereas it was $4,334,681 less in 1916.

The Webb City-Carterville-Prosperity district, which includes many of the "sheet ground" mines, was again much the largest producer of both blende and galena concentrates in southwestern Missouri. It produced 53 per cent of the galena concentrates and 38 per cent of the sphalerite sold in 1917.

The quantity of crude ore or "dirt" raised is a better indication of the extent of mining activity than the production of concentrates, for the "sheet ground" ore is of lower average tenor than the "soft ground" ore. The leading position of the district is more adequately shown by the fact that the estimated quantity of ore mined in the Webb City-Carterville-Prosperity district in 1917 was about 4,952,800 tons, or nearly 45 per cent of the total crude ore raised in southwestern Missouri, and that the output in 1917 was about 1,150,000 tons less than in 1916.

Unfortunately, the large decrease in the quantity of ore treated in 1917 in the Webb City-Carterville-Prosperity district does not convey an adequate idea of the great changes that occurred in 1917 and that have since culminated in the closing down of most of the large mines in the district and the removal of the concentrating plants. The large pumps at the Providence mine have been pulled and the water level is gradually rising. As many of the mines in the north and central Webb City camps are connected underground, it will be very expensive to unwater the properties, even if better ore prices make profitable the mining of "sheet ground" containing from 2 to 2.30 per cent in concentrates. The only new concentrating plant built in 1917 was by the O. & M. Mining Co., on the Fremont land. In the entire territory from Oronogo on the north to beyond Duenweg-Porto Rico on the south, the only large mills in operation in June, 1918, were the Bertha A., Coahuila, Hurry Up, Fairhope, Athletic, Ben Franklin, Kirkwood, Orange, and Davey. The following mills have been sold and removed: Wingfield, Milan, Sunshine, Nearby, Red Bird, McDonald, Victor, National No. 1, Cumberland, Bessemer, Schenley, Latoka, Cisco, Sunflower, and Chapman.

The production of lead and zinc concentrates in the Joplin district increased 7 per cent in 1917. Nearly all the increased output was in galena and zinc silicate. Mining was brisk during the early part of 1917, though new work was practically confined to "soft ground." Only a few of the "sheet ground" mines in the west Joplin camp were being worked at the end of the year, and the new mines opened were mainly those requiring the investment of only a small amount of money.

Some of the new concentrating plants built in 1917 were the King David on Connor land, Malsbury on Freeman land, Malcona on Johnson land, Little Bill on Higgins land, St. Regis No. 2, Cliff on American Zinc, Lead & Smelting Co.'s land, Fifteenth Street and Yellowstone on Missouri Lead & Zinc Co.'s land.

Duenweg-Porto Rico had a production of zinc and lead concentrates in 1917 which in the aggregate was only about 1,000 tons less than in 1916. More than 80 per cent of the output was from "sheet ground" mines, and as the only mines of that class in operation in June, 1918, are the Athletic and the Coahuila there will be a very large decrease in the production.

New mills were constructed in 1917 by the Hartford Mining Co. on the Barratt land, by Scott Mining Co. (rebuilt after destruction by fire) on the Irwin land, by C. M. & H. Mining Co. (dismantled also in 1917) on the Hackett land, and by M. M. & B. Mining Co. on the Carter land.

The Granby district produced 15,828 tons of zinc silicate and carbonate, which was more than 50 per cent of the total output of that class of zinc ore in Missouri in 1917. There were also shipments of 540 tons of galena and 6,126 tons of sphalerite, so that the value of the concentrates sold from that district was only exceeded in value by the shipments from Webb City, Joplin, and Duenweg. There was considerable drilling done outside the land of the American Zinc, Lead & Smelting Co., and a good production was made from the Zogg and the Douglas lands.

The quantity and value of the concentrates shipped from the Oronogo district in 1917, though less than in 1916, exceeded the quantity and value of the Alba-Neck City district, which had an output of about 5,000 tons less sphalerite concentrates than in 1916. There were no striking developments in either district other than the work continued at the Oronogo Circle mine in removing the overburden by means of steam shovels in order to obtain a large supply of ore for the new 1,000-ton mill.

The less productive mining districts in the Joplin region which showed an increased output of lead and zinc in 1917 were Wentworth, Carthage, Spurgeon-Seneca, and Diamond. New mills were constructed at Carthage by the Coahuila Zinc & Lead Co. and at Diamond by the Neosho & Granby Mining Co. The Sarcoxie-Reeds, Spring City, Cave Springs, Zincite-Klondike, and Thoms Station districts all had much decreased outputs and the only mine of any importance at Sarcoxie was that of the Flannery Zinc Co., which rebuilt the plant destroyed by fire in December, 1916.

The only plant at Carl Junction operated in 1917 was the Lucky Shot and the tailing plants built at Stott City in 1916 were abandoned in 1917 after short runs.

Several new plants were constructed near Springfield, Mo., early in 1917 and operated for a few months until the low price of sphalerite forced them to cease operations.

The production at Aurora was only slightly less in 1917 than in 1916. A new mill was built by Matthes, Phelps Co., and the Daisy Bell mill was moved to the Schmook land.

The principal producers in Christian County were the W. N. Fink Mining Co. on the W. E. Bain land, the Robertson Mining Co. on the Deeds land, and the Bray Mining Co. on the Arnold land. All the mines are in the Ozark district, and concentrating plants were erected at the two first-mentioned properties.

Considerable prospecting and drilling was done near Seymour, in Webster County, by the Chaffin-Simmons Mining Co., and near Mansfield, in Wright County. A small quantity of ore was shipped from Mansfield by the R. S. & T. Mining Co and the Red Bird Mining Co., and the Mansfield Mining & Development Co. has drilled its leases and erected concentrating plants.

The production from Howell and Taney counties in 1917 was confined to a few tons of zinc carbonate and silicate and the only output from Ozark County was that of Nixon, Gunn & Brosius, from the old Alice mine and that of the Southwestern Zinc Co.'s property, near Sharpe.

CENTRAL AND SOUTHEASTERN MISSOURI.

The ore deposits of central and southeastern Missouri reach in a more or less connected belt from the region of Benton, Pettis, Morgan, Moniteau, Cole, and Miller counties on the northwest to the northern and eastern flanks of the St. Francis Mountains on the southeast. It is also true that there are scattered areas where more or less mining has been done all the way between the northwest end of this belt and the Joplin region, so that strictly speaking the lead and zinc deposits of Missouri practically form a zone around the northern half of the Ozark dome. A brief description of the ore deposits in central and southeastern Missouri is given in the separate chapter entitled "Silver, copper, lead, and zinc in the Central States in 1915," which can be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

The ore in the southeastern Missouri region is almost wholly lead, although a considerable zinc deposit occurs at Valle mines, some 6 miles north of the Bonneterre district, and a considerable quantity of zinc silicate is mined in various parts of Washington and Jefferson counties. A certain percentage of zinc is also found in the disseminated lead ore, the ore from one shaft being reported to run occasionally as high as 2 per cent of zinc for a week at a time. The zinc occurs more plentifully in the Leadwood-Flat River district and may lie near the contact of the Bonneterre limestone with the Lamotte sandstone or some distance above it. In the lead concentrates zinc ranges from 1 to 5 or more. In the maximum proportions mentioned the zinc makes trouble in lead smelting, and for this reason some of the concentrating plants remove the zinc as a table middling.

Copper, nickel, and cobalt also occur in the ore, in considerable quantity in the vicinity of Fredericktown, and in small quantity, irregularly, in nearly all the deep mines. It is only near Fredericktown that the copper, nickel, and cobalt content of the ore has been the object of mining, yet a concentrate of these metals has been recovered as a table middling at several plants in other parts of the district, and 3,115 tons of copper concentrates were shipped in 1915, 2,878 tons in 1916, and 2,304 tons in 1917. From these copper concentrates 354,753 pounds of copper were recovered in 1917. In the disseminated ore district the production since 1869 increased rapidly and is estimated by Buckley to have amounted to 1,202,607 tons of lead concentrates, valued at $59,869,354, for the period between 1869 and 1906, inclusive. The mine production of southeastern and central Missouri has been reported to the United States Geological Survey since 1907.

Mine production of lead and zinc concentrates in southeastern and central Missouri, 1907-1917.

Year.	Lead concentrates—galena.		Zinc concentrates.			
			Sphalerite.		Carbonate and silicate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1907	156,663	$7,910,398	100	$3,500	1,095	$15,330
1908	183,095	6,906,116	42	1,050	1,369	20,436
1909	210,620	8,823,297	41	938	1,284	17,334
1910	210,890	9,360,309	....	....	929	19,000
1911	219,145	10,293,400	113	3,990	510	11,576
1912	218,803	9,849,854	40	1,292	1,051	21,020
1913	219.511	9,580,893	33	574	639	13,491
1914	249,165	9,710,125	40	700	497	11,282
1915	278,104	12,773,579	43	1,064	1,061	39,460
1916	307,025	20,720,737	365	14.400	1,030	42,129
1917	306,473	30,070,995	186	16,344	293	7,145

A comparison of the estimates for the period of years to 1906 given by Winslow and Buckley for Washington and St. Francois counties (which have supplied a very large proportion of the galena ores from southeastern and central Missouri) with the figures in the preceding table indicates a production of galena concentrates during the last 11 years much greater than the entire output of southeastern and central Missouri prior to 1907.

The lead ore of southeastern Missouri carries a small proportion of silver, the average being less than 1 troy ounce to the ton of lead concentrates. The resulting pig lead likewise carries silver, together with a little copper, nickel, cobalt, and traces of antimony and arsenic, and is sometimes commercially known as "Missouri chemical" lead in contradistinction to "Missouri soft" lead from the Joplin region. An average of about 15 per cent of the total lead concentrates from southeastern Missouri is desilverized. The silver so recovered does not pay for the refining charges, but the desilverized lead commands a slightly higher price, making up the difference. As the silver content of the concentrates is so small, it is disregarded in their sale, and therefore the smelter reports are relied upon for the production of silver. As already explained, the quantity of silver produced during any year bears no direct ratio to the quantity of silver-bearing lead concentrates smelted during that year, for the reason that the silver bullion is stored and refined in batches at convenient times.

The output of silver in Missouri in 1917 was derived almost entirely from lead concentrates, the only other source of production being about 2,400 ounces recovered from copper ore and from copper concentrates recovered in dressing lead ores, which were shipped to smelters.

The production of silver in southeastern Missouri was 61,586 fine ounces in 1917, as compared with 129,450 fine ounces in 1916, 57,756 fine ounces in 1915, 61,168 fine ounces in 1914, 35,620 fine ounces in 1913, 35,438 fine ounces in 1912, 49,867 fine ounces in 1911, 33,096 fine ounces in 1910, 14,188 fine ounces in 1909, and 49,131 fine ounces in 1908. The production of silver in 1917 was recovered from 76,222 tons of lead concentrates and from copper ore and concentrates that averaged a little more than 1 ounce a ton.

The crude lead ore mined in the disseminated lead district in 1917 amounted to 5,887,900 short tons, against 5,467,500 short tons in 1916, 5,067,400 short tons in 1915, 4,718,300 short tons in 1914, 4,250,800 short tons in 1913, and 4,064,366 short tons in 1912. The crude ore in 1917 yielded 5.03 per cent of lead concentrates, which averaged 66.7 per cent of lead. The average value per ton of the lead concentrates in 1917 was $98.01, as compared with $67.47 in 1916, and the concentrates were slightly higher in lead content than in 1916. The output of galena concentrates was 306,473 tons, valued at $30,070,995, in 1917, against 307,025 tons, valued at $20,720,737 in 1916. As several of the large producers not only mine but also smelt their lead concentrates, the values given for concentrates are arbitrary to a certain extent. The galena concentrates produced in the southwestern Missouri region containing a higher lead content are mainly sold on bids from various purchasers, and the prices for those lead concentrates are not comparable with prices given for concentrates of the disseminated lead district.

Analyses of ores mined in disseminated lead district in southeastern Missouri and of the various grades of resulting concentrates.[a]

	Ag	Cu	Pb	SiO_2	Fe	Al_2O_3	CaO	MgO	Zn	S	Ni and Co
	Ozs. per short ton.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ore (crude)	0.12	0.06	5.7	5.0	4.1	4.9	25.5	14.2	0.8	2.0	......
High-grade concentrates	.7	.13	73.2	1.0	3.5	....	2.6	.8	.4	15.0	0.05
Medium-grade concentrates	1.3	.12	68.6	1.4	4.6	....	3.1	1.4	.8	15.5	.06
Low-grade concentrates	1.0	.30	65.8	.5	3.1	.5	4.3	2.8	1.7	13.7	......
Flotation slimes, concentrates	......	.50	45.0	9.6	4.4	3.1	7.5	4.2	4.0	12.3	......
Flotation slimes, high-grade concentrates	3.7	.05	57.8	6.0	2.7	....	2.2	1.4	9.4	15.5	......
Joplin (southwestern Missouri) concentrates	......	......	80.2	1.1	1.0	....	.4	......	1.7	13.3	......

[a] Garlichs, Herman, Metallurgy of lead ores in the lower Mississippi Valley: Am. Inst. Min. Eng. Bull., July, 1917, pp. 1041-1046.

NOTE.—A typical analysis of southeastern Missouri undesilverized lead is as follows: Ag, 0.0080 (2.4 oz. per short ton); As, trace; Sb, 0.0030; Bi, trace; Cu, 0.0800; Fe, 0.0015; Zn, trace; Ni and Vo, 0.0080; lead by difference, 99.8995.

The production of sphalerite from central and southeastern Missouri in 1917 amounted to only 186 tons, valued at $16,344, which was only one-half the production of 1916. The production of zinc carbonate from southeastern Missouri in 1917 amounted to 293 tons, against 1,030 tons in 1916.

Nearly all the zinc carbonate was shipped by the Merseal Allee Timber Co. and the Valle Mining Co., both in Jefferson County, and the sphalerite was shipped by the Bluff Springs Mining Co. and by the Pearce Mining Co., in Morgan County. The Bluff Springs Mining Co. abandoned the mine near Tipton and is opening a barytes and lead deposit near Centertown, in Cole County. The production of galena and zinc carbonate from the Valle mines was much less than usual and very few lessees were working. The company's work was mainly that of sinking new shafts.

The quantity of galena recovered from shallow diggings in Washington and Jefferson counties was only about 400 tons. The high wages paid by the large mines in St. Francois and Madison counties attracted miners and laborers who normally lease and work many of the shallow diggings. The ore, which occurs at shallow depths and in association with barytes, is mined in a small way and at odd times by the barytes miners. This ore is all hand picked and cleaned, there being no concentrating plants. There are numerous other shallow lead and barytes diggings scattered over Washington County which are worked by small operators and farmers, who sell their product to the country merchants and to ore buyers. Much of this ore was purchased by J. F. Evans, of Potosi, and P. G. Higginbotham, of Fertile.

Although the production of galena concentrates from the disseminated lead district was about the same in 1917 as in 1916, the value of the output showed a large increase. The foreign laborers were attacked by the native miners in July, 1917, and military authority was necessary before order was restored. Few lives were lost but considerable damage was done to property of foreigners.

The St. Joseph Lead Co., which includes the old Doe Run property, produced more than one-half the lead production of southeastern Missouri. Seven shafts, ranging from 400 to 500 feet in depth, were operated in 1917. The concentrating plant operated in the Flat River district has a capacity of 4,000 tons a day, that at Bonne Terre 2,400 tons, and that at Leadwood 1,800 tons. All mill machinery, mine hoists, pumps, and compressors are motor driven. The two gas-producer electric plants at Rivermines and Bonne Terre were shut down upon the completion of the new 6,000-kilowatt steam turbine plant at Rivermines, which with the steam turbine plant at Leadwood now supplies power for all mining and milling operations.

The Desloge Lead Co. also had an increased output. Three shafts having an average depth of 366 feet were operated in 1917 and a new filter plant and other equipment were added to the concentrating plant, which has a capacity of 1,500 tons a day. The installation of Myers-Whaley shoveling machines and gasoline motors for underground haulage reduced the cost of mining very considerably.

The Federal Lead Co. operated four shafts in 1917, mining and milling 1,870,000 tons of crude ore. Early in 1917 a new concentrating plant of 3,000 tons capacity per day was put in commission and was served by the new No. 12 shaft. This mill, which is known as No. 4 mill, is most substantially constructed of reinforced concrete and steel and represents the latest practice in lead concentration of southeastern Missouri ores. The older mill, known as mill No. 3, has a capacity of 4,800 tons.

The mines and mills of the Federal Lead Co. are at and near Flat River, St. Francois County, Mo.

The Phoenix Lead Co. and the Fleming property in Madison County, near Fredericktown, Mo., were operated under lease by the Federal Lead Co., but operations there were closed at the end of the year.

The mines of the St. Louis Smelting & Refining Co. are in the vicinity of the village of St. Francois, about 1 mile north of Flat River. The concentrating plant is modern, having a capacity of 2,500 tons per day of 24 hours, and is equipped with Hancock jigs, Overstrom classifiers, and Butchart tables, and slime and settling tanks. A central steam-power plant drives air compressors and electric generators. The mill, hoists, and pumps are operated by electricity as well as the underground haulage and the trams for handling the ore from the shafts to the mill. This company also operates a lead smelter and refinery at Collinsville, and the lead concentrates produced by the mines and also those derived from crude ore purchased from the Baker Lead Co. and the Boston Elvin Lead Co. were smelted at that plant.

The Baker Lead Co., which owns the Jake Day tract near Big River, operated one shaft 400 feet in depth. There is no concentrating plant on the property and the ore was hauled to the National mill of the St. Louis Smelting & Refining Co., to which the crude ore was sold.

The Boston Elvins Lead Co., which owns a 40-acre tract at Elvins, also sold its crude ore. The shaft at this mine is 650 feet deep and 3-ton skips were used for hoisting ore. Operations were commenced in April, 1917, and continued until July, when the pumping equipment broke down and the mine remained flooded until the end of the year. A new centrifugal pump has been installed and the mine will be unwatered.

The old Mine La Motte property, in Madison County, which was taken over by the Missouri Metals Corporation, in addition to the shipment of lead concentrates to the St. Louis Smelting & Refining Co., produced and shipped a considerable quantity of copper concentrates. In certain parts of the property copper and nickel-cobalt sulphides occur, but the mining of such ores had been avoided in recent years until the Missouri Metals Corporation took over the property. Some silver was recovered from the copper concentrates in 1917, but no nickel or cobalt was recovered.

The ore deposits at Mine La Motte are relatively shallow, and the mine development during 1917 was largely in the nature of diamond drilling and in stripping the overburden to bed rock so that the property can be worked by open cuts and all underground mining can be suspended. The crushing plant had been completed and the large picking plant under construction will be finished and operated in July, 1918. The concentrating tables and other mill machinery have been rearranged to accommodate the increased quantity of ore handled by the new crushing plant.

The Buckeye or North American mine at Fredericktown was unwatered by the Missouri Cobalt Co. There were two shafts in operation, and a concentrating plant of 300 tons capacity and a 100-ton smelter were completed in 1917. A new refinery for the treatment of cobalt, nickel, and copper was under construction. The lead concentrates produced will be smelted at the Federal plant and the copper concentrates containing nickel and cobalt will be shipped to the Commercial Acid Co., of St. Louis, for making sulphuric acid. The cinders from the copper concentrates will then be returned to the smelter and refinery of the Missouri Cobalt Co. for the recovery of the cobalt, nickel, and copper.

OKLAHOMA.

By J. P. Dunlop.

PRODUCTION.

Production of lead and zinc in Oklahoma in 1917.

District.	Ores.					
	Lead concentrates (galena).		Zinc concentrates.			
			Sphalerite.		Carbonate and silicate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Ottawa County:						
Miami	32,557	$3,280,853	158,722	$10,704,968		
Quapaw	208	19,781	934	57,356		
Peoria	10	900			124	$4,931
Murray County—Davis					144	4,197
	32,775	3,301,534	159,656	10,762,324	268	9,128
Total, 1916	15,344	1,283,789	55,124	4,118,723	509	25,621

District.	Metal content.[a]			
	Lead.		Zinc.	
	Quantity (short tons)	Value.	Quantity (short tons).	Value.
Ottawa County:				
Miami	26,186	$4,503,992	85,266	$17,394,264
Quapaw	164	28,208	478	97,512
Peoria	8	1,376	45	9,180
Murray County—Davis			46	9,384
	26,358	4,533,576	85,835	17,510,340
Total, 1916	12,115	1,671,870	28,754	7,706,272

[a] In calculating the metal content of the ores for assays, allowance has been made for smelting losses of zinc, but not of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average sales price of all grades. The zinc price is the average sales price of all grades reported by smelters.

The following table gives the output of crude lead and zinc ore for the whole State of Oklahoma, but it was thought advisable to calculate the tenor of crude ore and concentrates as well as assay content and value of concentrates separately for the Miami and Quapaw districts, inasmuch as the character of the ground operated in these districts has, until the new mines in the easterly extension of the Miami district, near Quapaw, were opened in 1918, differed so radically that general calculations for the State would be valueless:

Tenor of lead and zinc ore and concentrates produced in Oklahoma, 1916 and 1917.

		1916	1917
Total crude ore milled in Oklahoma	short tons	1,406,900	3,523,200
Miami district:			
Total concentrates in crude ore:			
Lead	per cent	1.15	0.94
Zinc	do.	4.03	4.56
Metal content of crude ore:			
Lead	do.	.91	.76
Zinc	do.	2.33	2.72
Average lead content of galena concentrates	do.	79.0	80.4
Average zinc content of sphalerite concentrates	do.	57.77	59.6
Average value per ton:			
Galena concentrates		$83.94	$100.77
Sphalerite concentrates		$74.80	$67.44
Quapaw district:			
Total concentrates in crude ore:			
Lead	per cent	.07	.51
Zinc	do.	2.42	2.30
Metal content of crude ore:			
Lead	do.	.06	.41
Zinc	do.	1.31	1.32
Average lead content of galena concentrates	do.	77.0	78.8
Average zinc content of sphalerite concentrates	do.	54.2	56.9
Average value per ton:			
Galena concentrates		$71.79	$95.10
Sphalerite concentrates		$75.30	$61.41

The chapter on the production of lead and zinc in Oklahoma in Mineral Resources for 1914 contains a brief history of mining in the various districts and also the estimated total production of each district, by years.

Mine production of lead and zinc concentrates in Oklahoma, 1891-1917.

District.	Lead concentrates (mainly galena).		Zinc concentrates.			
			Sphalerite.		Zinc silicate and carbonate	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Peoria	2,042	$96,098	97	$3,129	2,679	$71,724
Quapaw	3,829	241,860	31,589	1,368,632	164	2,692
Miami	90,043	6,744,824	336,395	19,542,614	....	....
Davis	....	....	558	27,399	899	24,592
	95,914	7,082,782	368,639	20,941,774	3,742	99,008

The total value of the lead and zinc concentrates produced in Oklahoma in 1917 was approximately 159 per cent greater than in 1916 and followed an increase of 127 per cent in 1916.

The lead and zinc deposits of northeastern Oklahoma, so far as known, are confined to the limits of Ottawa County and form the southwestern extension of the Joplin region. There are three camps, Peoria, Quapaw, and Miami, in this county, in which extensive mining has been done, and a fourth, the Sycamore Creek district, along the Seneca fault block from 2 to 3 miles southwest of Seneca, Mo., in which considerable prospecting has been done and some ore mined.

The lead and zinc deposits in southern Oklahoma are near Ravia, at the southeast end of the Arbuckle Mountains, and near Davis, Murray County, at the northwest end of the same range.

The quantity of crude ore milled in Oklahoma increased from 1,406,900 tons in 1916 to 3,523,200 tons in 1917, notwithstanding that the quantity of ore milled by the old mines near Commerce was less in 1917 than in 1916.

The value of the recoverable lead and zinc produced at mines in Oklahoma in the year 1917 was $22,043,916, compared with $9,378,142 in 1916. The metal content of lead concentrates increased from 12,115 tons, valued at $1,671,870, in 1916, to 26,358 tons, valued at $4,533,576, in 1917, and the recoverable zinc increased from 28,754 tons, valued at $7,706,272, to 85,835 tons, valued at $17,510,340.

In 1917 the lead concentrates produced in the Oklahoma districts were of considerably higher grade than those shipped in 1916. The average metal content of the sphalerite concentrates from Miami ore increased from 51.8 per cent in 1912 to 53.6 per cent in 1913, to 54.8 per cent in 1914, to 55.7 per cent in 1915, to 55.77 per cent in 1916, and to 59.6 per cent in 1917, and was 2.7 per cent more than the average metal content of the sphalerite from the Quapaw district in 1917.

The lead concentrates from Oklahoma sold in 1917 were 17,431 tons more in quantity and $2,017,745 greater in value than in 1916. Miami district produced more lead than any other district in the Joplin region, exceeding the Webb City-Carterville district by about 12,000 tons, and its yield was equal to about 43 per cent of the production of the Joplin region. The Oklahoma shipments of sphalerite in 1917 amounted to 159,656 tons, valued at $10,762,324, an increase of 104,532 tons in quantity and of $6,643,601 in value.

The shipments of zinc carbonate and silicate decreased from 509 tons in 1916 to 268 tons, valued at $9,128 in 1917. The Miami district yielded about 96 per cent of the sphalerite concentrates and more than 99 per cent of the galena concentrates sold in Oklahoma in 1917.

Peoria district.—The production at Peoria, the oldest mining camp in the State, was only a few tons of galena and 124 tons of zinc silicate, most of which was mined by R. E. Lauck, on the Geboe land. This property was purchased by the Silver Crown Mining Co., and it is reported that a sublessee, the Mount Nebo Lead & Zinc Co., is building a mill.

Davis district.—The production from the Davis district, in Murray County, southern Oklahoma, in 1917, was 144 tons of zinc silicate, which was mined at shallow levels and shipped by the Grace Mining Co., I. Adler, and McGuire & Coffee.

Quapaw district.—There was a large amount of drilling, shaft sinking, and mill construction in the Quapaw district, especially in that part lying in the immediate vicinity of the town of Quapaw. The total production of concentrates, however, was less in 1917 than in 1916. The sales of galena increased from 61 tons in 1916 to 208 tons in 1917, and those of sphalerite decreased from 1,986 tons in 1916 to 934 tons in 1917. The total value of the concentrates sold in 1917 was $77,137, a decrease of about 50 per cent. There should be a large increase in the production of both lead and zinc in 1918, even if only a part of the new mills built and now under construction are operated. Many leases at the Lincolnville and Sunnyside camps were acquired by new owners and drilled to levels lower than the ore bodies worked in former years. Many new mines were opened in the town of Quapaw, and immediately south, north, and west of that town, which has grown from a small village to a bustling, business community. Among the new mines and old properties which have been opened and reopened, most of which have been equipped with concentrating plants or hand jigs, are the Sambo and the Myrtle on the Buck land, the Aurora Mining Co., Old Reliable Mining Co., Canton Mining Co. (old Mission), O. T. Oil & Gas Co. (old Katy), Hawkins Lead & Zinc Co., Lead Boy Mining Co., Morgan Zinc Co., Red Rose Mining Co., True Blue Mining Co., Benson Kirtley Mining Co., Bethlehem Zinc Co., National Lead & Zinc Co., Muskogee Lead & Zinc Co., Red Eagle Mining Co., Hare Development & Operating Co., Quajack Mining Co., McCurdy Mining Co., Springfield Mining Co., Kentex Mining Co., Miami District Mining Co., White Swan Mining Co., Allied Mining Co., Prairie Dog Mining Co., Scott Eagle Mining Co., Associated Lead & Zinc Co., Doris Mining Co., and St. Louis Lead & Zinc Co.

Miami district.—A history of the mining in this district, including the output by years for the period 1908 to 1914, and the location of the mines and mills, was given in this report for the year 1914, copies of which can be obtained on request. The reports for the years 1915 and 1916 contain full reviews of the production, new territory prospected, new mines opened, and new mills erected in those years.

A brief description of the ore deposits in the Miami district of Oklahoma is given in the separate chapter of Mineral Resources entitled "Zinc in 1915," [1] which can be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

The mines of the Miami district in 1917 shipped 32,557 short tons of galena concentrates, valued at $3,280,853, and 158,722 short tons of sphalerite concentrates, valued at $10,704,968, an increase of 17,412 tons of galena concentrates and of 105,776 tons of sphalerite concentrates when compared with the output of 1916. The average price of the galena concentrates increased about $23 a ton, but the average price of sphalerite concentrates, of which 5 times as much was shipped, decreased $14 a ton.

The unusual increase of more than 100 per cent in the quantity of galena and of 200 per cent in the quantity of sphalerite does not adequately show the active development which continued from 1916 into 1917. It is difficult to realize the possibilities of the output had there not been some shortage of labor and supplies and lower prices of sphalerite. It is questionable whether it was advisable to force such rapid development, or rather production, in face of high operating costs and declining values. Many of the mines recovered large quantities of galena which made operation profitable, notwithstanding the much lower selling price of sphalerite. The operating costs at Miami are greater than in most of the districts in the Joplin region and the royalties paid average 50 per cent more. The "dirt" or ore mined in 1917 averaged 1.50 per cent more in concentrates than that of all the "dirt" from "soft ground" treated in southwestern Missouri, and the average quantity of galena in the "dirt" at Miami was three times as great. The increased recovery of concentrates in the Miami district compensated for the higher operating costs, but it is certain that some of the Miami mines could not have profitably mined ore during the last part of 1917.

---

[1] See also Siebenthal, C E., Zinc: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, pp. 888-890, 1917.

The extension of the Mineral Belt Railway to the northerly end of the district and the completion of the extension of the Southwestern Missouri Electric Railway from Galena, Kans., to the Hockerville and Picher camps have provided adequate transportation facilities for the entire district.

The production in 1917 in the Miami district was that of about 80 mills, of which 15 were in the old Commerce camp and the remainder in the territory north and northeast to the Kansas State line and east to Quapaw. Many of the mills were not operated until the latter part of the year and others were operated intermittently. It is estimated that in June, 1918, there were more than 200 concentrating plants—many of them of large capacity—built or under construction in Ottawa County. It is impossible to give a close estimate of the output in 1918 other than that the production of sphalerite concentrates in the Miami district will probably exceed 225,000 tons, even if the prices of sphalerite do not advance. The only mines which are at present having difficulty in controlling an excessive quantity of water are those lying southeast of Picher and north of Quapaw. Many properties north and west of Treece are delayed in producing concentrates on account of the heavy flow of water. These properties, though in the extension of the Miami district, are in Kansas.

The quantity of crude ore mined and milled increased from approximately 1,314,800 tons in 1916 to 3,479,900 tons in 1917. The percentage of concentrates recovered from crude ore milled was larger than in any other district in the Joplin region, and, with increased operations in the northern part of the district, the ore treated showed an increase in percentage of concentrates recovered from 5.18 per cent in 1916 to 5.50 per cent in 1917. The average increase in recovery from ore was larger than the figures indicate, for a considerable quantity of old tailings was rerun in the old Commerce camp. As a larger proportion of the output of the Miami district in 1917 was derived from mines north of Commerce, which usually yield zinc concentrates of higher grade than those near Commerce, the average metal content of all blende concentrates sold increased from 57.77 per cent in 1916 to 59.6 per cent in 1917. The average metal content was 51.8 per cent in 1912, 53.6 per cent in 1913, 54.8 per cent in 1914, and 57.7 per cent in 1915, so that the total increase in the zinc content of the sphalerite sold has been more than 7 per cent in five years.

The separate assays reported showed the zinc content to range from 48 to 63 per cent, but most of the blende assayed between 55 and 59 per cent. Assays of 741 lots of zinc concentrates in 1917 by Thor Relling, of Miami, showed an average content of 59.10 per cent zinc, 1.30 per cent lead, 1.90 per cent iron, and 0.95 per cent lime, and the average content of 240 lots of galena concentrates assayed was 79 per cent lead and 1 per cent iron. These assays reported by Relling very closely approximate the average lead content of galena concentrates and the zinc content of sphalerite concentrates given in the table for the Miami district, though his assays did not include any of the high-grade concentrates produced at the Picher mines. The average selling price of galena concentrates increased from $83.94 in 1916 to $100.77 in 1917, and that of blende concentrates decreased from $74.80 in 1916 to $67.44 in 1917.

The recovery of galena concentrates from all the mines averaged about 1 ton to 5 tons of sphalerite, which is much higher than in any other district in the Joplin region. The proportion of galena concentrates recovered from the "dirt" mined showed wide variations, ranging in different mines from less than 1 ton of galena to 100 tons of sphalerite to 1.4 tons of galena to 1 ton of sphalerite. The mines lying north and northeast of the Quapaw mine near Commerce reported 27,999 tons of galena and 150,336 tons of sphalerite; those lying southwest of the Quapaw mine to the southern limits of the district reported 4,558 tons of galena and 8,387 tons of sphalerite.

The only production in the Horse Shoe Lake camp and the small area lying southwest of Commerce was that of a small quantity of sphalerite from the McConnell land. A new concentrating plant was built by the Green Zinc Co., which was not operated because of an inadequate supply of water for milling.

The old mines at Commerce, the Mispah mine, the farthest south, those on the northwesterly ore run extending to the old Haymaker mine, and those on the northeasterly ore run as far as the Quapaw mine are located on the Emma Gordon and the Commerce Mining & Royalty Co. leases. The producers on Emma Gordon land that shipped concentrates in 1917 were the Standifer Mining Co., High Five Mining Co., Miami Zinc & Lead Co., H. C. & S. Mining Co. (Prairie), and the Haynes Mining Co. which acquired all the interest of the Welch Mining Co. in the Carson mines. The Haynes Mining Co. sunk a winze to the depth of 360 feet, but the development of the ore found at that level was discontinued until prices of ore were better.

The productive mines on leases in the immediate vicinity of Commerce on land of the Commerce Mining & Royalty Co., were the Cactus (Tango shaft), Lost Trail, Mispah, Turkey Fat, King Jack (The Concentrating Co.), Midas, Old Chief, Miami Amalgamated (Sullivan), and the Eureka, now called the T. H. C. Mining Co. Of these mines the Mizpah, Cactus, and Turkey Fat mines were operated by the controlling interests in the Commerce Mining & Royalty Co.

The Worley Mining Co., which was being operated on old tailings and ore from the Old Chief mine was burned in July, 1917, and was not rebuilt. The Quapaw and the Lennan mines on Commerce land at the northeastern limits of the town of Commerce, hoisted ore taken from levels as low as 375 feet, which was the deepest mining in the district.

Those mines situated in the new camps in the vicinity of Tar River, Picher, Douthat, St. Louis, and Hockerville, treated about 3,100,000 tons of crude ore, which yielded 27,999 tons of galena concentrates and 150,335 tons of sphalerite, an average recovery of 0.90 per cent in galena concentrates and 4.86 per cent in sphalerite concentrates and a total recovery of 5.76 per cent. As some of the large mines reported a recovery as high as 7 to 10 per cent, many of the mines must have treated ore that yielded only 3 to 4 per cent, or even less, in concentrates. It is difficult to segregate the producing mines according to camps, but most of the production in 1917 came from the vicinity of Picher, Tar Creek, and Douthat (Century), as the mines near St. Louis and Hockerville were developed last.

The total shipments of those properties which may properly be classed as in the Tar River-Douthat area, of which there were a greater number than in the other areas, were 19,863 tons of galena and 101,512 tons of sphalerite. Slightly less than 2,100,000 tons of "dirt" was milled, so that the recovery in concentrates averaged about 6 per cent. A few of the mines yielded nearly as much galena as sphalerite, in other mines the proportion of galena was as little as 2 per cent.

Among the large producers of galena were the O. M. Bilharz Mining Co., Commerce Mining & Royalty Co. (Blue Goose and Beaver mines), Oklahoma Woodchuck Zinc Lead Co., Central Lead & Zinc Co., Velie Mines Corp., and the Admirality Zinc Co. The largest shippers of sphalerite in 1917 were the Skelton Lead & Zinc Co., Admiralty Zinc Co., Montreal mine, Bethel and Croesus mines, U. S. Smelting & Mining Co., and the Underwriters Land Co.

The other properties in the Tar River-Douthat camp from which were shipped lead or zinc concentrates were the Roanoke, Golden Rod (Nos. 1, 2, 3, and 4), Laclede, Jay Bird, Kitty, Lucky Junction, Republic, Wireck, Vinegar Hill (Wilson mine), Goodeagle, Mihoma, Anna Beaver, Missouri Mule, Potosi, Rialto, Ramage, Manhattan, and Lucky Kid, all of which properties are equipped with one or more concentrating plants, many of which are of large capacity.

Many transfers of lands and leases, some of them reported to be for considerations in excess of a million dollars, were made. The Welch Mining Co. leases equipped with four mills were acquired by the Skelton Lead & Zinc Co. The Golden Rod Mining & Smelting Co. took over a large area of proved ground, including the Mihoma and old McConnell mines, and now own 7 mills, of which 4 produced concentrates in 1917. Aikins, Curtis & Cosden bought the Admiralty Zinc Co. leases and 4 concentrating plants. The O. M. Bilharz Mining Co. has 3 mills, one each at the Blue Bird, Short Horn, and Chapman mines. The Velie Mines Corp. also has 3 mills called the Lion, Panther, and Leopard.

The following mines have been equipped with shafts and milling plants which were not completed or not operated in 1917: Carnegie, Federal, Greening, Kanoak, Pittsburg-Miami, Imperial, Niangua, Boomerang, Lucky Syndicate, Wingfield, Larsh, Triangle, Early Bird, Dorothy Bill, and Sinden.

Although many drills were operated, shafts sunk, and new concentrating plants built in the Hockerville and St. Louis camps east of Picher, there were only five mines from which concentrates were shipped in 1917. About 54,000 tons of ore were milled and 120 tons of galena and 3,859 tons of sphalerite concentrates recovered. The sphalerite averaged more than 60 per cent zinc content and the output of galena was proportionately much less than in other parts of the Miami district. The St. Louis Smelting & Refining Co. has 2 mills of 500 tons capacity each, which are among the best in the Joplin region. No. 1 mill was operated in 1917, but heavy water prevented No. 2 mill from being started. Underwriters mill No. 2, which is northwest of the St. Louis No. 2, had a large output for the short period operated after completion. The other producing mines in this section were the Mahutska, Lucky Jack, and Sequoyah, and shafts were sunk and mills have been built at the following mines; Farmington, Golden Eagle, Merrill (Huttig), Lucky Strike, Choctaw Chief, Blue Bonne, Mary Ann, Black Eagle, and Melrose.

The production of the mines in the vicinity of Picher showed a large increase in 1917. The total quantity of ore treated was 947,800 tons, and 8,016 tons of galena and 44,964 tons of sphalerite concentrates were shipped. Most of the output was that of the Eagle Picher Lead Co., which operated the Whitebird, Bingham, Crawfish, Netta, Goodwin, Perin, and Potter mills, and three flotation plants. The production of both galena and sphalerite by this company was much larger than any other operator in the Miami district. In addition to the output of the mines and mills operated by this company there was a large production from ground subleased to the Vantage Mining Co., St. Joe Mining Co., Piokee Mining Co., Dewdrop Mining Co., and William F. White Mining Co. Other mines from which concentrates were shipped in 1917 were the Acme Mining Co., Commonwealth Mining Co., Walker Mining Co., Trustee Mining Co., and Hare Mining & Milling Co.

Mills which have been constructed but which were not operated in 1917 are the Tiger, Texas, Standard, Ottawa, Billiken, Buffalo, Royal, Premier, Chicago-Miami, New Chicago, Big Chief, Keltner, Leonora, Producers, Beulah B., Grace Walker, Midas, Santa Fe, and Swift.

WISCONSIN.

By J. P. Dunlop.

PRODUCTION.

Production of lead and zinc in Wisconsin in 1917.

District.	Ores.					
	Lead concentrates.		Zinc concentrates.			
	Galena.		Sphalerite.		Silicate and carbonate.	
	Quantity (short tons).	Value.	Quantity (short) tons).	Value.	Quantity (short tons).	Value.
Benton-New Diggings	2,779	$266,930	134,186	$3,870,772	430	$12,850
Cuba City	57	5,789	955	19,350	....	....
Dodgeville	130	14,245	1,769	45,180	....	....
Haze Green	123	8,925	10,991	287,710	18	540
Highland	301	23,390	2,977	90,523	1,206	43,963
Linden	724	67,348	14,442	377,727	....	....
Livingston	408	43,741	26,570	639,037	....	....
Mifflin	174	17,462	15,036	426,072	....	....
Mineral Point-Montfort	71	6,527	1,195	58,690	646	10,481
Platteville and Potosi	325	33,562	10,623	501,509	....	....
Shullsburg	452	44,662	5,172	286,147	....	....
	5,544	532,581	223,916	6,602,717	2,300	67,834
Total, 1916	4,187	291,397	201,220	7,395,600	4,261	68,544

Production of lead and zinc in Wisconsin in 1917—Continued.

District.	Metal content.[a]			
	Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Benton-New Diggings	2,095	$360,340	36,026	$7,349,304
Cuba City	45	7,740	166	33,864
Dodgeville	101	17,372	493	100,572
Hazel Green	71	12,212	2,363	482,052
Highland	204	35,088	1,040	212,160
Linden	524	90,128	3,514	716,856
Livingston	323	55,556	5,500	1,122,000
Mifflin	134	23,048	3,536	721,344
Mineral Point-Montfort	52	8,944	562	114,648
Platteville and Potosi	245	42,140	4,084	833,136
Shullsburg	345	59,340	2,458	501,432
	4,139	711,908	59,742	12,187,368
Total, 1916	3,043	419,934	56,803	15,223,204

[a] In calculating the metal content of the ores for assays allowance has been made for smelting losses in the case of zinc, but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average sales price of all grades. The zinc price is the average sales price of all grades reported by smelters.

Tenor of lead and zinc ore and concentrates produced in Wisconsin, 1916 and 1917.

	1916	1917
Total crude ore ... short tons	3,066,500	3,014,800
Total concentrates in crude ore:		
Lead ... per cent	0.14	0.18
Zinc ... do	6.72	7.42
Metal content in crude ore:		
Lead ... do	.10	.13
Zinc ... do	2.26	2.44
Average lead content of galena concentrates ... do	72.7	74.7
Average zinc content of sphalerite concentrates ... do	34.4	32.8
Average zinc content of zinc carbonate concentrates ... do	21.0	26.7
Average value per ton:		
Galena concentrates	$69.59	$96.06
Sphalerite concentrates	$36.75	$29.48
Zinc carbonate concentrates	$16.32	$29.49

The lead and zinc mines of Wisconsin are in Grant, Iowa, and Lafayette counties and comprise the most important part of the ore deposits of the upper Mississippi Valley region, a historical review of which is given in the Illinois section of this report in Mineral Resources for 1914. A detailed description of the Wisconsin lead and zinc districts and of the mines in each district to the year 1906 is given by Bain.[1] Although mining development has continued and many new mines have been opened, worked out, and abandoned, the area of the mining region has not been enlarged to any extent. The development of the mines subsequent to Bain's report and the output of Wisconsin mines have been given in the reports in Mineral Resources of the United States for the years 1907 to 1916.

The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age. The ores are galena, sphalerite or zinc blende, with smithsonite or zinc carbonate, the last locally known as "dry bone." As a lead region the district has been known from the earliest settlement days. In time the building of smelters near by made a market for the zinc ores. The first zinc ore to be mined was the carbonate found in association with lead in the shallow working above ground-water level. When all the main deposits were worked out down to water level there was a lull in mining in the region. Though the carbonate was known to give place to zinc blende and the lead to continue on below water, it was not deemed profitable to mine when continued pumping was necessary. About 1900 the higher price of zinc led to the opening of some of the deposits below water level, since which time zinc mining has increased until Wisconsin ranks among the largest of the zinc-producing States. The ore bodies are found in perpendicular, horizontal, or inclined cavities known as "openings" or "crevices," "flats," and "pitches." The openings sometimes extend for a considerable distance in a straight line called a "range," and may be mined at different places by different companies. When a range is once established it becomes an important guide in prospecting.

---

[1] Bain, H. F., Zinc and lead deposits of the upper Mississippi Valley: U. S. Geol. Survey Bull. 294, pp. 81-148, 1906.

The galena of the district is nonargentiferous, and so far as known the zinc ores are free from cadmium. In some of the mines marcasite is so plentiful that the zinc blende concentrates are reduced to a very low grade. Owing to their nearness in specific gravity, marcasite and blende are very difficult to separate cleanly by hydraulic methods.

Roasting and electromagnetic separation have been utilized in the district for many years—and especially in the last three years—to produce a marketable zinc product. The green sulphide concentrates are roasted in cylindrical roasters to drive off a little sulphur and render the iron sulphide magnetic after which they are treated on electromagnetic separators and yield blende concentrates assaying from 56 to 60 per cent and pyrites tailings, which are purchased by manufacturers of sulphuric acid. Comparatively few of the concentrating plants are equipped with roasters, but practically all the larger mining interests own or control separating plants. Two plants for making sulphuric acid are now under construction which will use the residues from the roasting plants and also the output of some mines which yield a marcasite ore containing small quantities of zinc sulphide.

The roasting and separating plants operated in 1917 were those of the Mineral Point Zinc Co., at Mineral Point, the Linden Zinc Co., at Linden, the Champion plant of the Wisconsin Zinc Co., at New Diggings, the National Zinc Separating Co. and the Zinc Concentrating Co., at Cuba City, the Utt-Thorne Co., at Benton, the Kistler & Stevens Co., at Platteville, and the Oliver Mining Co., at Shullsburg, in Wisconsin, and the Wisconsin Zinc Co., at Galena, Ill.

The average zinc content of the raw sphalerite concentrates sold in 1917 was 32.8 per cent and the average price per ton was $29.48; the corresponding content and price for 1913 were 38 per cent and $21.53; for 1914, 35.05 per cent and $17.73; for 1915, 36.5 per cent and $38.37; and for 1916, 34.4 per cent and $36.75.

The percentage of concentrates recovered from crude ore is much higher than in the Joplin region, but the zinc concentrates average 22 to 25 per cent less in zinc content. On account of these conditions, at many mines no close recovery is made, and the tailings, containing large quantities of zinc, are seldom reworked. The new concentrating plants, however, are being equipped with more tables than formerly. The concentrates from the tables have a very high iron content, but this can be remedied by roasting.

The crude ore yields from 5 to more than 20 per cent of concentrates. The average recovery in concentrates increased from 6.86 per cent in 1916 to 7.60 per cent in 1917, which was a natural reflection of the lower price of sphalerite concentrates. The mining methods are largely determined by the mode of occurrence of the ores, but otherwise are similar to those in vogue in working the pockety ores at Joplin. The milling methods used in the Wisconsin field have been given by Walter Schultz,[1] of the Wisconsin Zinc Co.

The zinc carbonate ore, which is mined principally in the Highland, Benton, and Mineral Point districts, is purchased mainly by the Mineral Point Zinc Co., and made into zinc oxide in the plant at Mineral Point, Wis.

The metal content of the raw sphalerite concentrates sold by the mines varied in 1917 from 18.3 to 56 per cent. The larger portion of the concentrates sold ranged between 28 and 38 per cent. The zinc content of the roasted sphalerite concentrates shipped varied from 57 to 60 per cent.

The value of the mine output of lead and zinc in Wisconsin for the year 1917 was $12,899,276, against $15,643,138 in 1916, a decrease of $2,743,862.

The lead concentrates sold increased from 4,187 tons, valued at $291,397 in 1916 to 5,544 tons, valued at $532,581, in 1917. The sphalerite concentrates sold increased from 201,220 tons to 223,916 tons, though the value of such concentrates decreased from $7,395,609 to $6,602,717.

The quantity of zinc carbonate concentrates shipped decreased from 4,261 tons in 1916 to 2,300 tons in 1917, and the value decreased from $68,544 to $67,834.

The metal content of the lead concentrates in 1917 was 1,096 tons more than in 1916. The recoverable zinc content of the sphalerite and zinc carbonate concentrates in 1917 increased 2,939 tons.

There was less than the normal amount of development work done, as the scarcity of labor, high cost of supplies, and the declining price of sphalerite discouraged many small investors and prospectors. The increase in the production of sphalerite was entirely that of a few large operating companies. The higher prices paid for galena concentrates resulted in greater activity at those mines which recover galena from ore bodies at shallow levels. The concentrating plants built or moved and reconstructed in 1917 were the Bearcat and Hird No. 3, of the Frontier Mining Co., at Benton; the Hoskins, of the Mineral Point Zinc Co., at New Diggings; the Meloy, at New Diggings, and the Jefferson, at Hazel Green, of the Vinegar Hill Zinc Co.; the North Survey, at Dodgeville; the C. S. & H. (old Roosevelt), at Cuba City; Lucky Six No. 2 (under construction), at Linden; New Empire and the New Rose, at Platteville; the Copeland, of the Wisconsin Zinc Co., at Shullsburg, and the Mud Range, at Potosi.

The larger mining interests in the Wisconsin field, which include the Mineral Point Zinc Co., Wisconsin Zinc Co., Vinegar Hill Zinc Co., Frontier Mining Co., and Field Mining & Milling Co., had a combined output approximately equal to 50 per cent of all the lead concentrates and 74 per cent of all the zinc concentrates shipped from Wisconsin mines in 1917. Mines controlled by the Optimo Mining Co., Cleveland Mining Co., Saxe, Pollard & Co., and Utt, Thorne & Co., contributed substantially to the output in 1917.

---

[1] Schultz, Walter, Milling Wisconsin lead-zinc ores: Eng. and Min. Jour., July 14, 1917, pp. 82-84.

For descriptions of the old mines and concentrating plants on which no essential changes were made during 1917, the reader is referred to the corresponding section of this report in Mineral Resources for 1914, 1915, and 1916.

The Benton-New Diggings district produced about 50 per cent of the galena, 19 per cent of the zinc carbonate, and 60 per cent of the sphalerite shipped from Wisconsin in 1917. Its output was more than five times that of Livingston, the next largest producing district. The districts in Wisconsin that had a smaller production of zinc concentrates in 1917 than in 1916 were Cuba City, Linden, Platteville, Montfort, and Hazel Green. The quantity of ore treated was about 62,000 tons less in 1917 than in 1916, and the quantity of green sphalerite concentrates recovered was 11 per cent larger than in 1916. The average zinc content decreased from 34.4 per cent in 1916 to 32.8 per cent in 1917.

The shipments from the Benton part of the Benton-New Diggings district in 1917 were 1,499 tons of galena, 60,328 tons of sphalerite, and 165 tons of zinc carbonate. The shipments from New Diggings camp were 1,280 tons of galena, 73,858 tons of sphalerite, and 265 tons of zinc carbonate.

The Indian Mound mine at New Diggings was sold to the Laurence Mining Co., and the Connecting Link mine at Cuba City and the Optimo Mining Co. at Linden are reported to be building new concentrating plants in 1918.

The following mines were closed down or abandoned in 1917: Hodge, Klar Piquette, Bell, and West Hill at Platteville, Winskill and Crawhall at Benton, and the Rundell at Livingston. The operation of other properties has been suspended until higher ore prices or reduced costs make it possible to operate them profitably.

UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS ON GOLD, SILVER, COPPER, LEAD, AND ZINC IN THE CENTRAL STATES.[1]

Adams, G. I., Zinc and lead deposits of northern Arkansas: Bull. 213, pp. 187–196, 1903. 25 cents.

Adams, G. I., and others, Zinc and lead deposits of northern Arkansas: Prof. Paper 24, 118 pp., 1904. 40 cents.

Bain, H. F., Lead and zinc deposits of Illinois: Bull. 225, pp. 202–207, 1904. 35 cents.

——— Lead and zinc resources of the United States: Bull. 260, pp. 251–273, 1905. 40 cents.

——— Zinc and lead ores in 1905: Mineral Resources U. S. for 1905, pp. 379–392, 1906. $1.

——— Zinc and lead deposits of northwestern Illinois: Bull. 246, pp. 56, 1905. 15 cents.

——— Zinc and lead deposits of the upper Mississippi Valley: Bull. 294, 155 pp., 1906. 75 cents.

——— Reported gold deposits of the Wichita Mountains, Okla.: Bull. 225, pp. 120–122, 1904. 35 cents.

---

[1] The publications for which a price is given are no longer available for free distribution but can be purchased from the Superintendent of Documents, Washington, D. C.; others can be obtained free on application to the Director of the United States Geological Survey. Some are out of print but may be examined in libraries.

BAIN, H. F., VAN HISE, C. R., and ADAMS, G. I., Preliminary report on the lead and zinc deposits of the Ozark region: Twenty-second Ann. Rept., pt. 2, pp. 23-228, 1902. $2.25.

BAIN, H. F., and ULRICH, E. O., The copper deposits of Missouri: Bull. 260, pp. 233-235, 1905. 40 cents.

BUTLER, B. S., and SIEBENTHAL, C. E., Silver, copper, lead, and zinc in the Central States in 1909 (mine production): Mineral Resources U. S. for 1909, pt. 1, pp. 495-531, 1911. 60 cents.

BUTLER, B. S., and DUNLOP, J. P., Silver, copper, lead, and zinc in the Central States in 1910 (mine production): Mineral Resources U. S. for 1910, pt. 1, pp. 611-674, 1911. 75 cents.

——— Idem. For 1911, pp. 793-872, 1912. 90 cents.

——— Idem. For 1912, pp. 437-521, 1913. 90 cents.

——— Idem. For 1913, pp. 81-171, 1914. 70 cents.

——— Idem. For 1914, pp. 27-124, 1915. 75 cents.

CLERC, F. L., The mining and metallurgy of lead and zinc in the United States: Mineral Resources U. S. for 1882, pp. 358-386, 1883. 50 cents.

DUNLOP, J. P., and BUTLER, B. S., Silver, copper, lead, and zinc in the Central States in 1915 (mines report): Mineral Resources U. S. for 1915, pt. 1, pp. 45-137, 1917. See also Butler, B. S., and Dunlop, J. P.

——— Idem. For 1916, pp. 53-157, 1917.

ELLIS, E. E., Zinc and lead mines near Dodgeville, Wis.: Bull. 260, pp. 311-315, 1905. 40 cents.

GRANT, U. S., Zinc and lead deposits of southwestern Wisconsin: Bull. 260, pp. 304-310, 1905. 40 cents.

GRANT, U. S., and BURCHARD, E. F., Geol. Atlas, Lancaster-Mineral Point folio (No. 145), 1907. 5 cents.

IRVING, R. D., The copper-bearing rocks of Lake Superior: Mon. 5, 464 pp., 1883. $1.85.

LINDGREN, WALDEMAR, Resources of the United States in gold, silver, copper, lead, and zinc: Bull. 394, pp. 114-156, 1909. 40 cents.

——— Tests for gold and silver in shales from western Kansas: Bull. 202, 21 pp., 1902. 5 cents.

SIEBENTHAL, C. E., Mineral resources of northeastern Oklahoma: Bull. 340, pp. 187-228, 1908. 30 cents.

——— Origin of the zinc and lead deposits of the Joplin region, Missouri, Kansas, and Oklahoma: Bull. 606, 283 pp., 11 pls., 1915. 25 cents.

SMITH, W. S. T., Lead and zinc deposits of the Joplin district, Missouri-Kansas: Bull. 213, pp. 197-204, 1903. 25 cents.

SMITH, W. S. T., and SIEBENTHAL, C. E., Geol. Atlas, Joplin district folio (No. 148), 1907. 50 cents. Apply to Geological Survey.

ULRICH, E. O., and SMITH, W. S. T., Lead, zinc, and fluorspar deposits of western Kentucky: Bull. 213, pp. 205-213 (25 cents), 1903; Prof. Paper 36, 218 pp., 1905. 40 cents.

VAN HISE, C. R., and LEITH, C. K., The geology of the Lake Superior Region: Mon. 52, 1911. $2.50.

WINSLOW, ARTHUR, The disseminated lead ores of southeastern Missouri: Bull. 132, 31 pp., 1896. 5 cents.

GOLD, SILVER, COPPER, AND LEAD IN ALASKA.

(MINES REPORT.)

By G. C. Martin.

INTRODUCTION.[1]

The mineral output of Alaska in 1917 was valued at about $40,000,000. This is less than the output in 1916, which was nearly $50,000,000, including metals and nonmetals, but is greater than the output in any other year. The decrease was chiefly in copper, the production of which fell from 119,854,839 pounds, valued at $29,484,291, in 1916, to 88,793,400 pounds, valued at $24,240,598, in 1917. The reduction in the output of copper was due largely to labor troubles, which included a strike at the Kennecott mine and a shortage of labor at other mines. The production of gold declined about $2,500,000, and was the smallest since 1904. The reduction in output of gold was due chiefly to curtailment of operations because of the scarcity of labor and the high cost of materials, but in part also to the disaster from cave-in at the Treadwell mine in the month of April and to the depletion of some of the richer placers. There was a reduction in the output of silver, which was due to the decrease in production of gold and copper. The value of the silver produced in Alaska in 1917 was, however, the greatest in the history of mining in that Territory. The production of lead increased slightly.

PRODUCTION.

The following table gives an estimate of the total production of gold, silver, copper, and lead since the beginning of mining in 1880. The figures for the earlier years, especially for silver, are probably far from being correct, but they are based on the best information now available.

---

[1] The data on mining conditions and production here given are abstracted from a paper by G. C. Martin, published in United States Geological Survey Bulletin 692. Mr. Martin was assisted in the statistical work by T. R. Burch. The original paper and the papers that accompany it treat the subject at greater length than is desired here and should be consulted by those who require the more detailed information. Some of the figures here given are revisions of those in the original paper.

Gold, silver, copper, and lead produced in Alaska, 1880–1917.

Year.	Gold.	Silver.		Copper.		Lead.	
		Quantity (fine ounces).	Commercial value.	Quantity (pounds).	Value.	Quantity (tons).	Value.
1880	$20,000	10,320	$11,146	3,933	$826	...	...
1881	40,000			...	...	...	...
1882	150,000			...	...	...	...
1883	301,000			...	...	...	...
1884	201,000			...	...	...	...
1885	300,000			...	...	...	...
1886	446,000			...	...	...	...
1887	675,000			...	...	...	...
1888	850,000	2,320	2,181	...	...	...	...
1889	900,000	8,000	7,490	...	...	...	...
1890	762,000	7,500	6,071	...	...	...	...
1891	900,000	8,000	7,920	...	...	...	...
1892	1,080,000	8,000	7,000	...	...	30	$2,400
1893	1,038,000	8,400	6,570	...	...	40	3,040
1894	1,282,000	22,261	14,257	...	...	35	2,310
1895	2,328,500	67,200	44,222	...	...	20	1,320
1896	2,861,000	145,300	99,087	...	...	30	1,800
1897	2,439,500	116,400	70,741	...	...	30	2,160
1898	2,517,000	92,400	54,575	...	...	30	2,240
1899	5,602,000	140,100	84,276	...	...	35	3,150
1900	8,166,000	73,300	45,494	...	...	40	3,440
1901	6,932,700	47,900	28,598	250,000	40,000	40	3,440
1902	8,283,400	92,000	48,590	360,000	41,400	30	2,460
1903	8,683,600	143,600	77,843	1,200,000	156,000	30	2,520
1904	9,160,000	198,700	114,934	2,043,586	275,676	30	2,580
1905	15,630,000	132,174	80,165	4,805,236	749,617	30	2.620
1906	22,036,794	203,500	136,345	5,871,811	1,133,260	30	3,420
1907	19,349,743	149,784	98,857	6,308,786	1,261,757	30	3,180
1908	19,292,818	135,672	71,906	4,585,362	605,267	40	3,360
1909	20,411,716	147,950	76,934	4,124,705	536,211	69	5,934
1910	16,126,749	157,850	85,239	4,241,689	538,695	75	6,600
1911	16,853,256	460,231	243,923	27,267,878	3,408,485	51	4,590
1912	17,145,951	515,186	316,839	29,230,491	4,823,031	45	4,050
1913	15,626,813	362,563	218,988	21,659,958	3,357,293	6	528
1914	15,764,259	394,805	218,327	21,450,628	2,852,934	28	1,344
1915	16,702,144	1,071,872	543,393	86,509,312	15,139,129	437	41,118
1916	17,241,713	1,379,171	907,495	119,854,839	29,484,291	820	113,160
1917	14,657,353	1,239,150	1,021,060	88,793,400	24,240,598	852	146,584
	292,758,009	7,541,609	4,750,466	428,561,614	88,644,470	2,933	369,348

A small quantity of zinc was reported from one mine in 1917.

GOLD AND SILVER.

The following table gives an estimate, based on the best available data, of the source of the gold and silver produced in Alaska since mining began in 1880. About $65,100,000 in gold, or nearly one-fourth of the total estimated output, was produced before 1905, and there is only scant information regarding its source. For the production since that time fairly complete statistical returns are available, and the figures presented in the following table are probably approximately correct. The estimates given for the silver recovered from placer gold and from siliceous ores are perhaps less accurate than those for the gold. Copper mining did not begin in Alaska until 1901, and the figures for the gold and silver derived from that source are therefore a close approximation to the actual output.

Gold and silver produced in Alaska, 1880–1917, by sources.

	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
Siliceous ores[a]	4,066,066	$84,053,030	1,230,793	$842,129
Copper ores	75,561	1,561,987	4,607,493	2,946,627
Placers	10,020,542	207,142,992	1,703,323	961,710
	14,162,169	292,758,009	7,541,609	4,750,466

[a] Including small quantity of lead ore.

This table shows that about 28.5 per cent of the total gold produced in Alaska has been obtained from siliceous ores taken from auriferous lode mines. In 1917 the lode gold produced was 31 per cent of the total produced; in 1916, 38 per cent; in 1915, 37 per cent; in 1914, 32 per cent; in 1913, 31.6 per cent; and in 1912, 29 per cent. In the following table the production of precious metals in 1917 has been distributed as to sources:

Gold, silver, copper, and lead produced in Alaska in 1917, by sources.

Source.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Placers		474,558.75	64,410		
Dry or siliceous ores	3,414,664	221,505.73	131,631		1,688,168
Copper ore	659,951	12,830.16	1,040,185	88,790,310	
Lead, lead-zinc, and copper-lead ores	42	154.81	2,924	3,090	16,292
	4,074,657	709,049.45	1,239,150	88,793,400	1,704,460

LODE MINING.

Thirty-one lode gold mines were operated in 1917 and 9 prospects or small mines also produced gold but were not in regular operation. In 1916 29 lode mines were in operation. The value of the output of lode gold decreased from $5,912,736 in 1916 to $4,581,453 in 1917. Southeastern Alaska, especially the Juneau district, is still the only large quartz-mining region in the Territory. Next in lode output is the Willow Creek district. There was also considerable lode mining on Prince William Sound. The production in the Fairbanks district increased slightly, but lode-mine owners of Fairbanks are still awaiting the cheapening of operating costs, especially of fuel, which will be brought about by the Government railroad. Of the producing deep mines, 10 were in southeastern Alaska, 3 on Prince William Sound, 4 on Kenai Peninsula, 5 in the Willow Creek district, and 9 in the Fairbanks district. In 1917 the average value of the gold and silver contents for all siliceous ores mined was $1.37 a ton; the average for 1916 was $1.70 a ton. These averages show the dominance of the large quantity of low-grade ores treated in the Juneau district.

The production, by districts, of gold and silver in 1917 from lode mines, including small quantities from lead-silver mines (which can not be given separately without disclosing individual productions), is given in the following table:

Gold and silver produced from lode mines in Alaska in 1917.

District.	Mine operated.	Ore mined (short tons).	Gold.		Silver.		Average value per ton of ore in gold and silver.
			Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	
Southeastern Alaska	10	3,400,120	205,107	$4,239,914	129,691	$106,865	$1.28
Prince William Sound	[a] 3	5,350	4,509	93,208	697	575	17.53
Kenai Peninsula	4	140	223	4,614	124	102	33.68
Willow Creek	5	7,885	9,465	195,662	713	588	24.89
Fairbanks district [b]	[c] 9	1,200	2,311	47,781	2,217	1,827	41,34
Seward Peninsula [d]	([e])	5	13	274	145	119	78.60
	31	3,414,700	221,628	4,581,453	133,587	110,076	1.37

[a] Also five prospects.
[b] Includes some lead ore.
[c] Also two prospects.
[d] Lead ore.
[e] One prospect on Seward Peninsula, also one shipment from an unknown locality.

PLACER MINING.

The value of the placer gold produced in Alaska in 1917 was about $9,810,000; in 1916 it was $11,140,000. The decrease was due chiefly to restriction of operations by the high cost of supplies and the scarcity of labor. These adverse conditions were felt in all parts of Alaska and everywhere tended to reduce the output of gold. Production was increased only where local conditions permitted an expansion of the industry notwithstanding increased costs. Such conditions prevailed in some of the newly discovered camps, and consequently there was an increase in the output of placer gold in the Tolovana, Marshall, Tolstoi, and Koyuk or Dime Creek districts. The production of the Ruby district increased slightly owing to the very successful operation of the Greenstone dredge. There was also an apparent increase in the output of the Kuskokwim region, but this may be due to underestimates of the production in 1916.

About 610 placer mines were operated in the summer of 1917 and 200 during the preceding winter, but many mines were operated for only a part of the season. About 3,550 men were engaged in productive placer mining in the summer and 950 in the winter. In addition several hundred men were prospecting or were engaged in other nonproductive work relating to placer mining. The only new placer-bearing areas discovered in 1917 were in the Kuskokwim region, and these have not yet produced much gold.

The following table is based in part on returns made by operators of placers and in part on certain other information which is not available for 1917. The figures for 1917 are based on the assumption that the ratio of the recovery per cubic yard for the mines that supplied complete information to the recovery per cubic yard for all the mines is the same as in 1916. Therefore, although the table is only approximately correct it probably indicates the magnitude of the true figures.

Estimated quantity of gravel sluiced in Alaskan placer mines and value per cubic yard of gold recovered, 1908–1917.

Year.	Total quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.	Year.	Total quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.
1908	4,275,000	$3.74	1913	6,800,000	$1.57
1909	4,418,000	3.66	1914	8,500,000	1.26
1910	4,036,000	2.97	1915	8,100,000	1.29
1911	5,790,000	2.17	1916	7,100,000	1.57
1912	7,050,000	1.70	1917	5,900,000	1.68

This table shows that from 1908 to 1914 there was a decline in the average gold content of the gravels mined. This decline is a result of improved methods of placer mining, especially of the use of dredges, and if figures were available to show the average recovery of gold prior to 1908 they would indicate a far greater decline. The increase in the average recovery from 1914 to 1917 was made largely because most of the Alaskan dredges were working on far richer placer gravels and because in 1916 and 1917 a larger percentage of the placer gold came from the rich deposits of the newer districts, where gold recoveries of $7 to $20 a cubic yard are not uncommon. The movement of the miners away from the lower-grade placers, made evident by the average recoveries for 1915 to 1917, is the result of economic conditions due to the war, which affect gold mining more adversely than most other industries.

Thirty-six gold dredges were operated in Alaska in 1917, 2 more than in 1916. Twenty-eight dredges were in Seward Peninsula, 3 in the Iditarod, and 1 each in the Ruby, Fairbanks, Circle, Fortymile, and Yentna districts. These dredges handled about 3,700,000 cubic yards of gravel and produced gold valued at about $2,500,000. In 1916 the 34 dredges handled about 3,900,000 cubic yards of gravel and produced gold valued at $2,679,000. The average gold recovery per cubic yard was about 67½ cents in 1917 and 69 cents in 1916. The gold dredges of Seward Peninsula made an average recovery of 49 cents a cubic yard in 1917 and 53 cents in 1916. The dredges of the Alaska Yukon districts are working on placers of relatively high gold tenor, the value of gold recovery per cubic yard in 1917 being about 94 cents, whereas in 1916 it was about 85 cents.

Though dredges were built for use in the Alaska Yukon as early as 1898 and at Nome in 1900, this method of placer mining was not profitable until 1903, when two small dredges were successfully operated in Seward Peninsula. Dredging began in the Fortymile district in 1907; in the Iditarod, Birch Creek, and Fairbanks districts in 1912; and in the Yentna district in 1916. Up to the end of 1917 gold to the value of $17,610,000 had been mined by dredges. The distribution of this output by years is shown in the following table:

Estimate of gold produced from dredge mining in Alaska, 1903–1917.

Year.	Number of dredges operated.	Value of output of gold.	Year.	Number of dredges operated.	Value of output of gold.
1903	2	$20,000	1912	38	$2,200,000
1904	3	25,000	1913	36	2,200,000
1905	3	40,000	1914	42	2,350,000
1906	3	120,000	1915	35	2,330,000
1907	4	250,000	1916	34	2,679,000
1908	4	171,000	1917	36	2,500,000
1909	14	425,000			
1910	18	800,000		....	17,610,000
1911	27	1,500,000			

COPPER.

The production of copper in Alaska in 1917 was about 88,793,400 pounds, valued at $24,240,598. This is less than the production in 1916, which was 119,854,839 pounds, valued at $29,484,291, but is greater than the production in any other year. The reduction in the output for the year was due largely to scarcity of labor and to a strike at the Kennecott-Bonanza mine. During the year 17 copper mines were operated, compared with 18 in 1916. Of these mines 7 are in the Ketchikan district, 7 in the Prince William Sound district, and 3 in the Chitina district. Small shipments of copper were also made from nine prospects or mines not in regular operation.

Output of Alaskan copper mines, by districts, in 1917.

	Number of mines.	Ore.	Copper.		Gold.		Silver.	
		Quantity (short tons).	Quantity (pounds).	Value.	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
Ketchikan district	[a] 7	41,060	2,646,553	$722,509	2,338	$48,337	20,500	16,891
Chitina district	[b] 3	267,541	70,587,110	19,270,281	1	6	887,880	731,614
Prince William Sound [c]	[d] 7	351,356	15,559,737	4,247,808	10,524	217,557	132,773	109,405
	....	659,957	88,793,400	24,240,598	12,863	265,900	1,041,153	857,910

[a] Also small shipments from 2 prospects.
[b] Also a small quantity of placer copper and small shipments from 4 prospects.
[c] Including a small amount from Cook Inlet.
[d] Also small shipments from 3 prospects.

The average copper content of the ores mined in 1917 was 6.7 per cent. The ores also yielded an average of $0.40 in gold and $1.30 in silver per ton. The average yield for 1916 was 9.7 per cent of copper and $1.60 per ton in gold and silver. The decrease in the copper content in 1917 was due to the smaller proportion of high-grade Kennecott ores in the total production. The following table shows the total production of copper in Alaska:

Copper produced in Alaska, 1880–1917.

Year.	Ore mined (short tons).	Copper produced.	
		Quantity (pounds).	Value.
1880	[a] 40,000	3,933	$826
1901		250,000	40,000
1902		360,000	41,400
1903		1,200,000	156,000
1904		2,043,586	275,676
1905	52,199	4,805,236	749,617
1906	105,729	5,871,811	1,133,260
1907	98,927	6,308,786	1,261,757
1908	51,509	4,585,362	605,267
1909	34,669	4,124,705	536,211
1910	39,365	4,241,689	538,695
1911	68,975	27,267,878	3,408,485
1912	93,452	29,230,491	4,823,031
1913	135,756	21,659,958	3,357,293
1914	153,605	21,450,628	2,852,934
1915	369,600	86,509,312	15,139,129
1916	617,264	119,854,839	29,484,291
1917	659,957	88,793,400	24,240,598
	2,521,007	428,561,614	88,644,470

[a] Estimated.

Among the noteworthy features of copper mining in Alaska in 1917 was the continued enormous output of the Kennecott-Bonanza mine in the Chitina district which, as in previous years, overshadowed all other operations. The total output of the coastal mines increased in 1917. This increase was due largely to the greater production of the Beatson mine, although the aggregate production of the so-called independent mines was also larger than in 1916, notwithstanding the shortage of labor and ships. The larger production from the smaller low-grade mines is of course due to the high price of copper and will not be permanent for all the mines. However, some mines that are now being made productive or that are being worked on a large scale under the stimulus of high prices will perhaps be able to maintain their output when copper sells at a lower price, and the copper industry of Alaska will probably in general continue to advance, though it will doubtless meet temporary setbacks. Work preparatory to the production of copper was continued energetically on several of the nonproducing mines and prospects in all three of the Alaska copper districts. No new discoveries of note were reported.

LEAD.

The production of lead in Alaska in 1917 is estimated to have been 852 short tons, valued at $146,584, the largest production in the history of mining in Alaska. The production in 1916, the next largest, was 820 tons, valued at $113,160. Alaska lead is still, as in past years, derived chiefly from the concentrates at the gold mines at Juneau. The production in 1917 includes small quantities derived from the galena ores of the Fairbanks district and Seward Peninsula and from the copper-lead ores of southeastern Alaska. Though deposits of silver-lead ores are found in many parts of Alaska, most of them have not yet been opened for commercial mining. The production of lead in Alaska for the period 1892–1917, so far as it can be determined from available data, was 2,933 short tons.

REVIEW BY REGIONS.

SOUTHERN ALASKA.

LODE MINING.

Ten lode gold mines and 8 copper mines were operated in southeastern Alaska in 1917. The value of the mineral output of these mines was: Gold, $4,325,251; copper (2,646,553 pounds), $721,687; silver, $123,825; and lead, $145,182.

The largest mining operations in 1917, as in preceding years, were at the gold mines in the Juneau district. As a result of a cave-in at the Treadwell, 700-foot, and Mexican mines on April 21, these mines are now flooded with sea water and are not in operation.

All the productive copper mining in southeastern Alaska was done in the Ketchikan district. The development of the copper lodes of this district, particularly on Kasaan Peninsula, has at several places uncovered large bodies of magnetic iron ore, which are now being considered as possible commercial sources of iron.

Mining on Chichagof Island continued on about the same scale as in 1916. Development work on the group of copper claims near Pinta Bay, about 15 miles northwest of Chichagof, was also continued.

PLACER MINING.

Placer mining in southeastern Alaska was limited to the Porcupine district and to small beach operations at Yakataga and Lituya Bay.

COPPER RIVER REGION.

The largest mining operations in the Copper River region in 1917, as in several preceding years, were at the Jumbo and Kennecott-Bonanza copper mines. Considerable copper was also shipped from the Mother Lode mine, and small shipments were made from several other properties. The Jumbo and Kennecott-Bonanza mines and the mill at Kennecott were operated on a large scale throughout the year, although the production was considerably smaller than in 1916. This reduction in the output was due to a strike in midsummer of 1917 and to shortage of labor during much of the year.

Hydraulic placer mining continued on a large scale in the Nizina district, where 2 mines employing 4 miners were in operation in the winter of 1916–17 and 6 mines employing 91 miners in the summer of 1917. These mines produced about $120,000 in placer gold and a little placer copper. No important developments or discoveries were reported.

Placer mining on Slate Creek, in the Chistochina district, was continued on a large scale. The production of this district is estimated at about $100,000 in gold and 15 or 20 ounces of platinum.

PRINCE WILLIAM SOUND.

The value of the mineral production of the mines on Prince William Sound was $4,567,929 in 1917 as compared with about $3,000,000 in 1916. This figure represents the value of the product of 7 copper mines and 3 gold mines, which can be classed as regular producers, and of additional small shipments from 8 other small mines or prospects. The Beatson-Bonanza, Ellamar, and Midas mines were the largest producers. These mines and the Blackbird group, which began shipping after lying idle for several years, and the Schlosser and the Mackintosh properties employed more than 550 men during the year.

KENAI PENINSULA.

The mining production of Kenai Peninsula includes about $30,000 of placer gold, $4,600 of lode gold, a small quantity of silver obtained incidentally to the mining of gold, a considerable quantity of chromite mined at Port Chatham, and some lignite. There was very little activity in lode gold mining and little development was reported. The largest placer mining operations were on Resurrection and Crow creeks. Heavy rains in the fall caused serious damage at the placer mines throughout the district.

SUSITNA REGION.

WILLOW CREEK DISTRICT.

The mineral production of the Willow Creek district in 1917 included $195,662 in gold and $588 in silver, all derived from quartz mines. The quantity of ore milled was 7,885 tons. A promising new quartz vein which was opened at the Gold Cord mine, at the head of Fishhook Creek, has already been traced for the length of several claims.

YENTNA DISTRICT.

The Cache Creek district continues to be the principal source of placer gold in the Yentna basin. A dredge, burning local coal, was operated on Cache Creek, and 15 hydraulic plants were working on Cache and Peters creeks during the summer. More than 100 men were employed and produced placer gold valued at between $125,000 and $150,000. The operations at the end of the season were hampered by protracted rains and serious floods, which caused considerable damage to several mining plants. Late in the fall a Hudson dry dredge, which is to begin mining in the spring of 1918, was installed on ground along the north side of Kichatna River.

Platinum occurs in the gravels of the lower Kahiltna River, where prospecting for that metal was carried on by two companies. It occurs also at many other places in the Susitna basin, including Cache, Peters, Camp, and Lake creeks, as well as on Kichatna and Chulitna rivers, and commercial platinum placers may ultimately be found.

SUSITNA VALLEY.

The mineral production of the upper Susitna Valley is still restricted to the placer gold of the Valdez Creek district, but lodes in the Broad Pass and Talkeetna districts are being prospected. In 1916 and 1917 some twenty groups of claims were staked on gold and copper bearing lodes in the basin of Iron Creek, a tributary of Talkeetna River, but practically no underground work has yet been done. A new copper discovery is reported from the head of Maclaren River.

SOUTHWESTERN ALASKA.

The known mineral production in southwestern Alaska in 1917 consisted of small amounts of copper ore from the vicinity of Kamishak Bay and of placer gold from the Kodiak beaches, from a creek near Katmai Bay, and from Portage Creek, in the Clark Lake district.

YUKON BASIN.

GENERAL STATEMENT.

The value of the gold produced by the placer mines of the Alaska Yukon districts in 1917 is estimated to have been $6,583,000, compared with $7,550,000 in 1916. About 380 placer mines were operated in the summer of 1917, giving employment to about 2,550 men, and about 165 placer mines, employing about 790 men, were operated in the winter. Nine lode mines, all in the Fairbanks district, were productive in 1917. The following table gives the estimated gold output of the principal Yukon placer camps:

Estimated value of gold produced from placers in the Yukon Basin, 1917.

District.	Value.	District.	Value.
Iditarod	$1,500,000	Koyukuk	$250,000
Fairbanks	1,310,000	Circle	200,000
Tolovana	1,150,000	All others	413,000
Ruby	885,000		
Hot Springs	450,000		6,583,000
Marshall	425,000		

The Yukon placer mines also produced silver valued at about $39,000 in 1917. The figures in the table do not include the output of the lode mines, which in 1917 produced gold and silver valued at $49,607.

There was also a small output of tin from the Hot Springs district, and considerable tungsten ore and some antimony ore were mined in the Fairbanks district. The total value of the entire mineral production from the Alaska Yukon in 1917 was $6,747,835; that in 1916 was $7,839,757. Since mining began in 1880, the Alaska Yukon has produced minerals to the value of $110,800,000, most of which has been derived from the gold placers.

The most noteworthy feature of the placer mining of the year was the increased output of the Tolovana placers. There was also an increased production in the Marshall, Tolstoi, and Ruby districts. The other districts show a decrease in output, due chiefly to a general retrenchment by operators because of the high cost of supplies and the scarcity of labor.

FAIRBANKS DISTRICT.

The mineral production of the Fairbanks district in 1917 included placer gold, valued at $1,310,000; lode gold, valued at $47,781; placer silver, valued at $6,904; lode silver, valued at $1,827; and lead, tungsten, and antimony, valued at $58,257. The total value of the mineral output in 1917 was $1,424,769. The aggregate value of the entire mineral output of the district up to the close of 1917 is $70,417,000. Much the larger part of this amount represents the value of the placer gold, the production of which is shown by years in the subjoined table. In addition to the actual production of the district, about $1,000,000 in gold mined in tributary areas passes through Fairbanks each year.

Placer gold and silver produced in the Fairbanks district, 1903–1917.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1903	1,935.00	$40,000	348	$188
1904	29,025.00	600,000	5,225	2,821
1905	290,250.00	6,000,000	52,245	28,212
1906	435,375.00	9,000,000	78,367	42,318
1907	387,000.00	8,000,000	69,660	37,616
1908	445,050.00	9,200,000	79,909	43,151
1909	466,818.75	9,650,000	84,027	45,375
1910	295,087.50	6,100,000	53,116	28,683
1911	217,687.50	4,500,000	52,245	27,690
1912	200,756.25	4,150,000	48,182	29,632
1913	159,638.50	3,300,000	20,274	12,245
1914	120,937.50	2,500,000	29,024	16,050
1915	118,518.75	2,450,000	28,444	14,421
1916	87,075.00	1,800,000	11,058	7,276
1917	63,371.25	1,310,000	8,379	6,904
	3,318,525.00	68,600,000	620,503	342,582

No new discoveries or important developments in placer mining were made in 1917. A large dredge will be installed on upper Fairbanks Creek to begin operations in 1918.

Gold-lode mining in the Fairbanks district declined from 1913 to 1916, but showed a slight increase in production in 1917. The cost of supplies and fuel has become so high that many operators will wait for more favorable conditions rather than work at a low profit or run the risk of actual loss. Eight lode gold mines were worked in a small way and five of these operated their own mills. One silver-lead deposit is being worked and made an output in 1917. The following table shows the production of gold and silver from the Fairbanks lode mines since lode mining began:

Lode gold and silver produced in the Fairbanks district, 1910–1917.

Year.	Crude ore (short tons).	Gold.		Silver.	
		Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1910	148	841.19	$17,339	106	$57
1911	875	3,103.02	64,145	582	308
1912	4,708	9,416.54	194,657	1,578	971
1913	12,237	16,904.98	349,457	4,124	2,491
1914	6,526	10,904.75	225,421	2,209	1,222
1915	5,845	10,534.91	217,776	1,796	910
1916	1,111	1,904.81	39,376	140	92
1917	1,200	3,311.38	47,781	2,217	1,826
	32,650	55,921.58	1,155,952	12,752	7,877

CHISANA DISTRICT.

Placer mines were operated on Bonanza, Big Eldorado, Gold Run, and Little Eldorado creeks. These mines employed 44 men and produced gold valued at about $40,000. The population of this district is growing smaller year by year, although considerable prospecting is done on neighboring creeks in winter.

FORTYMILE DISTRICT.

The mineral production of the Fortymile district in 1917 consisted of gold valued at about $80,000, derived from 25 mines employing 68 miners, which were operated during the winter of 1916–17, and 35 mines employing 93 miners, which were operated in the summer of 1917. In addition to these mines a small dredge was operated in the summer of 1917.

EAGLE DISTRICT.

Twelve placer mines employing 25 men were operated in the Eagle district in 1917 and yielded gold valued at about $13,000. The largest number of mines and miners and the largest production was on American Creek.

CIRCLE DISTRICT.

Owing to unfavorable conditions, chiefly lack of rain during the later part of August and in September, the gold production from nearly all the creeks in the Circle district was greatly curtailed. The production was about $200,000, which is about $100,000 less than in 1916. About the same number of mines were operated and the same number of men were employed as in 1916. The chief developments in 1917 included the installation of a hydraulic plant on Independence Creek.

RAMPART DISTRICT.

The gold produced in the Rampart district in 1917 was valued at about $33,000 and was obtained from 2 mines, employing 5 men, in the winter of 1916–17 and 10 mines, employing 26 men, in the summer of 1917. The largest output was made on Hunter and Little Minook creeks.

TOLOVANA DISTRICT.

The output of the placer mines of the Tolovana district in 1917 was about $1,150,000, which is an increase of 50 per cent over that in 1916. About 50 mines were operated.

HOT SPRINGS DISTRICT.

The production of gold in the Hot Springs district in 1917 was about $450,000. Placer mines employing 190 men were operated on 30 claims, on Eureka, Sullivan, American, and Boulder creeks. The decrease in production is due in part to the cessation of large operations on Woodchopper Creek and in part to the high cost of food and mining supplies, which has prevented the working of any except high-grade ground.

RUBY DISTRICT.

The mining operations in the Ruby district in 1917 were conducted on about the same scale as in 1916 and resulted in the production of placer gold valued at $885,000, a little more than the production in 1916. It is reported that 19 mines, employing 310 men, were at work in the summer of 1917 and 19 mines, employing 520 men, in the winter of 1916–17. The largest production was made on Greenstone, Poorman, Long, Spruce, and Tamarack creeks. The dredge on Greenstone Creek had a successful season, but the dredging ground has been worked out and the dredge will be moved.

INNOKO DISTRICT.

The production of gold in the Innoko district in 1917 is estimated at $125,000. About 7 mines, employing 46 men, operated in the winter of 1916–17 and 20 mines, employing 78 men, in the summer of 1917.

TOLSTOI DISTRICT.

A stampede to the Tolstoi district took place in the winter of 1916–17. At times there were as many as 400 men in the camp, but not more than 50 remained in July. About $50,000 in gold was taken out during the winter and summer, the result of the operations of about 25 men on 5 plants, most of the production being on Boob Creek. Boob Creek is the only creek in the district that produced platinum. The platinum was not separated from the gold but was sold with it to the bank in Iditarod. The platinum in the gold was said to amount to about 1 per cent, so that about 30 ounces of platinum was produced.

IDITAROD DISTRICT.

The production of placer gold in the Iditarod district in 1917 was about $1,500,000, or $450,000 less than in 1916. The decrease was due largely to repeated breakdowns of the Otter Creek dredge. Detailed information concerning mining in this district is not available, but it is believed that in addition to the 3 dredges there were about 15 mines, employing nearly 400 men, at work in the summer of 1917 and 2 mines, employing about 10 men, in the winter of 1916–17.

KOYUKUK DISTRICT.

The total value of the gold produced in the Koyukuk district in 1917 was about $250,000, which is considerably less than the production in 1916. In the Indian River district 8 men were at work in the summer of 1917 on Indian Creek, Felix Fork, and Black Creek, and they produced about $4,000 in placer gold.

MARSHALL DISTRICT.

The production at Marshall was about $425,000, as compared with $270,000 in 1916. Most of this gold was produced by 5 mines on Willow Creek, employing about 200 men, but some smaller plants were at work on Willow, Disappointment, and Elphant creeks. A little platinum is found with the gold on some of the creeks at Marshall, but it is not saved.

SMALLER YUKON DISTRICTS.

At least four placers, employing 9 men, were in operation in the Chandalar district, where about $15,000 in gold was produced.

The Richardson district, of the Tanana region, apparently produced less than in 1916. No production has been reported from the Goodpaster region, though considerable prospecting has been done there.

There was no production of gold in the Gold Mountain district, but dead work was done preparatory to mining in 1918.

KUSKOKWIM REGION.

The production of gold in the Kuskokwim region in 1917, according to the best information at hand, was valued at $135,000. The largest production was on Candle and Moore creeks. The dredge that was shipped in the preceding year is to be placed at the upper end of Candle Creek. Another discovery is reported from Wahmus or Watermouse, in the Goodnews Bay district, where it is said that 4 men took out between $12,000 and $20,000 in three weeks.

SEWARD PENINSULA.

The mines of Seward Peninsula produced gold to the value of about $2,600,000 in 1917 as against $2,950,000 in 1916. The value of the total gold produced on Seward Peninsula since mining began in 1897 is about $76,892,000. Nearly all this gold was taken from placers. Silver and tin have been produced to the value of about $1,027,600, making the total value of the mineral output of Seward Peninsula to the end of 1917 about $77,900,000.

About 750 men were employed in placer mining in Seward Peninsula, exclusive of those employed on dredges. About half the number was employed in the Nome and Council precincts. One hundred and seventy plants were in operation.

Twenty-eight gold dredges were operated on the peninsula in 1917. Of these 7 were in the Nome district, 5 in the Solomon River district, 10 in the Council district, 2 in the Port Clarence district, 2 in the Fairhaven district, and 2 in the Kougarok district.

The production of gold on Dime Creek in 1917 was greater than in 1916, six plants making a very large part of the $150,000 produced by deep mining during late winter and early spring. An additional $20,000 will cover summer production, mostly from three open cuts. In all 17 plants worked during the winter and summer, employing about 85 men. This mining was done on four claims. Dime Creek produced about 35 ounces of platinum. The platinum content of the gold is about 1 ounce of platinum to $5,000 gold on the lower claims of the creek and on the bench claims, but is somewhat higher on claims near the head of the creek.

About $10,000 in gold was produced on Sweepstakes Creek, between Bear and Dime creeks, by 4 plants employing 11 men. About an ounce of platinum was separated from this gold.

Four plants, employing 14 men, worked on Bear Creek in 1917. The production of gold is not known, but this gold also contains platinum.

Exclusive of dredge production the gold produced in the Port Clarence precinct is estimated at $27,000. That produced in the Kougarok precinct, likewise exclusive of dredge production, is estimated at $55,000.

Most of the lode-mining developments on Seward Peninsula consisted of the necessary assessment work. The high prices of lead and silver gave an impetus to the search for those metals in the vicinity of Lost River and on the Kugruk, and considerable work was done in both localities.

KOBUK RIVER.

The production of the Kobuk district was probably about $25,000. Most of the mining was done on Klery Creek, but about 9 mines employing 16 men, were operated on Lynx, Riley, and Dahl creeks and on Shungnak River and made an estimated output of $5,000.

MAGNESIUM.

By Ralph W. Stone.

PRODUCTION.[1]

The production of metallic magnesium is a new industry in the United States, the first output on a commercial scale having been made in 1915. Prior to that year several firms had experimented in the isolation of the metal, but as the demand was small, as the known uses were few, and as a supply could be obtained from Germany, little progress was made toward commercial production. When the European war began not only was the German supply of the metal and of magnesium chloride from which it is extracted cut off but at the same time there arose a large demand. Whereas formerly only a small quantity, perhaps a few thousand pounds, had been used for flash lights in photography, the demand came for large quantities to be used in war materials.

In 1915 the total production of three firms was 87,500 pounds, valued at about $440,000. In 1916 four firms produced 75,400 pounds of magnesium, valued at $311,462. This production represented a reduction in 1916 of nearly 14 per cent in quantity and 29 per cent in value from the production of 1915. The average price fell from $5 a pound in 1915 to $4.13 a pound in 1916.

The output in 1917 was 115,813 pounds, valued at $233,626, and the total production in three years to December 31, 1917, as closely as can be determined from reports made by producers to the Geological Survey, was 278,713 pounds or about 139 short tons. This does not include small quantities which may have been made in an experimental way before 1915, nor is it exact because some of the producers, for lack of data, could report only in round numbers. The total value of the product in the first three years of the industry as determined from sales and from estimates based on average prices for the year, is $985,088.

The growth of the industry and improvements resulting in decreased cost of production are reflected in the following table:

Production of metallic magnesium.

Year.	Number of producers.	Quantity (pounds).	Value.	Average price per pound.
1915	3	87,500	$440,000	$5.00
1916	4	75,400	311,462	4.13
1917	5	115,813	233,626	2.02

---

[1] Statistical data in this report collected by Frank L. Hess, of the United States Geological Survey.

PRODUCERS.

The producers of magnesium at the end of 1917 were the American Magnesium Corporation, Niagara Falls, N. Y.; the Norton Laboratories (Inc.), Lockport, N. Y.; and the Rumford Metal Co., Rumford, Me. Other firms have produced or been interested in the production of metallic magnesium, but for one reason or another have dropped from the active list. The General Electric Co., at Schenectady, N. Y., was the pioneer producer on a commercial scale and made the principal output in 1915. Its primary reason for beginning the production of this metal was to assure a supply to the United States, and when in the latter part of 1917 there was a sufficient number of companies prepared to meet the demand it discontinued the production of magnesium. The Norton Laboratories (Inc.) began isolating magnesium about August 1, 1915, at Lockport, N. Y., where electric power from Niagara Falls is available. The office of this company is 296 Madison Avenue, New York City. The Electric Reduction Co. began producing magnesium in the fall of 1915 at Washington, Pa., and continued through part of 1916, until it was found more profitable to use the power for other purposes. The Aviation Materials Corporation, Niagara Falls, N. Y., which was reported ready for production at the end of 1915, was engaged during 1916 in perfecting a new process of isolating magnesium, and at the end of the year had accomplished this. It was succeeded by the American Magnesium Corporation, which was organized and began producing the metal in 1917. The Magnesium Manufacturing Corporation was completing its plant at the end of 1915 and began production the following year. This firm became the Rumford Metal Co., with an office at 200 Fifth Avenue, New York City, and operated throughout 1917. The Dow Chemical Co. has a metallic magnesium plant with a large capacity at Midland, Mich., but was unable to operate it in 1917, except in an experimental way, because of the lack of coal. This plant did not operate in 1916 and made only a small production in 1917.

PRICE.

Imported German magnesium was quoted at about $1.65 a pound in 1913, but after the European war cut off the foreign supply prices rose to $5 or even $6 a pound for sticks and $6.50 a pound for powdered material. These prices continued through 1915. During 1916 the price fell off, and at the beginning of 1917, 99 per cent pure bar magnesium was selling for $2.50 to $3 a pound. This price gradually declined, and at the end of 1917 magnesium in bars was selling for $1.85 to $2 a pound, according to the quantity bought.

Although the figures in the table above give an average price of $4.13 a pound for all production in 1916, one company reported an average price of $2.53, another $4.25, and a third $5. The reports for 1917 are in closer harmony, however, only one differing much from the general average of about $2 a pound.

IMPORTS AND EXPORTS.

The Bureau of Foreign and Domestic Commerce of the Department of Commerce records imports and exports of "barium, calcium, magnesium, sodium, and potassium, and alloys of which said metals are the component material of chief value," in one class, which is subject to a 25 per cent duty. Magnesium ribbon is subject to a 20 per cent duty, although it is in a more advanced state of fabrication than magnesium bars. No information is obtained by the customs officials regarding the imports and exports of magnesium alone. It is probable that little or none was imported in 1917 and that there was an increasing quantity exported to our allies.

CHARACTER.

Magnesium is the lightest of the metals now known that remain comparatively unaltered under atmospheric conditions. Its specific gravity is 1.74, or only two-thirds that of aluminum, which is 2.58. Magnesium is chemically inert, tough, and malleable, properties which should make the metal valuable in commerce.

Magnesium is a beautiful silvery-white metal. It is molded into round and square sticks from five-eighths of an inch to 2 inches thick and from 14 to 18 inches long. It is readily malleable and is ductile when heated. Magnesium ribbon is made by pressing the semifluid metal into wire and then flattening it. When heated in air, powdered magnesium burns rapidly with an intense white light and gives off abundant white smoke.

SOURCE OF METAL.

The metal has been obtained from magnesium chloride derived from bitterns left after the extraction of salt and bromide from brines at Midland, Mich., and from magnesite, the magnesium carbonate, which occurs as veins in serpentine at many localities in California and in beds like dolomite at Grenville, Quebec. Other possible sources of supply are dolomite, the magnesium-calcium carbonate, which occurs abundantly in the Eastern States, and the waters of the oceans and salt lakes. Ocean water contains only about 0.14 per cent of magnesium, but bitterns made around San Francisco Bay, Cal., by extracting salt from sea water contain from 2.3 to 8.6 per cent of magnesium. Magnesium chloride can be made from these bitterns, and some day the commercial production of magnesium from sea water near San Francisco may be a reality.

USES.

Magnesium is used in three forms, as a silvery powder or gray granular substance, as narrow ribbon, and as round or square sticks. Although its application in art, science, and manufacture is at present neither large nor varied, there is reason to believe that present conditions will develop new uses or so reduce the cost of production that magnesium can replace aluminum in some of its applications.

Magnesium in powdered form has been used for many years for flash lights in photography. Its value in this work is due to the fact that the intense white light it produces is rich in actinic rays, or those rays that produce chemical reaction on the photographic plate. In order that it may burn very rapidly, magnesium designed for this purpose is reduced to powder that will pass a 200-mesh screen. For taking moving pictures in dark places, which requires an intense and long-burning light, magnesium is mixed with a variety of other less inflammable constituents to lengthen the time of burning. Coarse powdered magnesium is used in the chemical laboratory in qualitative tests for phosphorus, and material not so fine as flash-light powder is used in fireworks, because of the beautiful effect of the brilliant white light and clouds of white smoke it gives off. The quantity used for this purpose never was large and with the change in method of celebrating festal occasions is probably decreasing. Magnesium powder is used in making war munitions and flares for military purposes. It is put in shrapnel shells so that the burning magnesium, which makes a white cloud by day and a dazzling white light by night, will show the gunners and observers where the shells are bursting. Magnesium is used in large quantities in aerial bombs and rockets for lighting contested territory at night, and it has other important military uses.

Magnesium in ribbon form is used in small quantity in chemical laboratories in the determination of potash and in qualitative tests for phosphorus. There are other special uses, such as the ignition of thermite mixtures, that consume a small quantity of ribbon annually.

Magnesium in massive form, as sticks or rods, is used in alloys both as a deoxidizing agent and as a constituent, as a dehydrating agent, and as an electrode in electrolysis. These four uses of massive magnesium may be briefly described as follows: A deoxidizing metal is a substance whose oxide is more stable or insoluble than the material to be deoxidized. The use of a metal for this purpose is called scavenging—that is, clearing up oxides of other metals and making denser and more homogeneous alloys. In alloying other metals various other substances as silicon, phosphorus, and aluminum are used to remove oxygen. The oxide of magnesium is more stable at high temperatures than any of these, and therefore metallic magnesium would seem to offer promising possibilities in this use, especially to replace aluminum as a deoxidizer of steel. The value of magnesium as a deoxidizer is utilized by adding it to Monel metal (nickel and copper) or nickel when melted for casting. It has been used in steel for the same purpose and in the reduction of boron. It can be used as a scavenger for copper, brass, bronze, and other metals and alloys.

Magnesium is used as an alloy with aluminum. Aluminum containing a small percentage of magnesium is used in the construction of airplanes and automobiles. This alloy is lighter than aluminum, has greater tensile strength and resistance to shock, is apparently equally resistant to corrosion, and is equal to aluminum also in electrical conductivity. Several United States patents have been issued for alloys of magnesium with other metals in varying proportions. An alloy consisting of 92 per cent magnesium and 8 per cent aluminum, which is covered by U. S. patent 965485 (1910), is reported to have a specific gravity of 1.75 and a strength equal to that of gun metal. An aluminum-magnesium alloy containing not over 2 per cent magnesium and known as magnalium is used in Europe for kitchen utensils, forks, knives, spoons, tableware, funnels, piano frames, skates, and parts of spinning, weaving, and milling machines; and in military equipment magnalium has found use in saddle skeletons, horseshoes, tent poles, instruments for surgical, optical, and chemical purposes, telegraph, telephone, and wireless apparatus, watch cases, and medals.

Magnesium may be used in dehydrating oils. When introduced in the form of small sticks it decomposes the water at 35° C., giving off hydrogen and forming magnesium oxide (MgO), which separates out.

This method has been used in Europe to free aniline from its small content (about 2 per cent) of water.

The use of magnesium has been suggested as a cathode in electrolysis where it is wished to prevent the reduction at the cathode in neutral or alkaline solutions which contain no ions of the heavy metals, and also in the electrolysis of alkali chlorides for hypochlorite. Magnesium anodes can be used in the contact process for producing galvanoplastic deposits of nickel and cobalt.

. In consequence of the improvement in methods of production, reduction in cost, and experience derived from the present demands, it is reasonable to assume that the uses of magnesium and its alloys will increase in this country until eventually magnesium may become as common as aluminum.

DEMAND AND SUPPLY.

Because of its high price and few known uses the demand for magnesium before 1915 was small. During 1916 and 1917 the use increased rapidly, especially for war materials, and it is safe to say that the quantity of magnesium consumed by the Allies on the western front in 1918 will be hundreds of tons.

The world's principal source of magnesium before the war was Germany, because that country was a large producer of magnesite and magnesium chloride, the materials from which the metal is derived. The elimination of that source has caused England, France, and Italy to turn to this country and to Canada for magnesium. To meet this call the three plants in the United States and one in Canada increased their output in 1917 more than 50 per cent over that of 1916, and in 1918 they will doubtless more than double the production of 1917.

The supply of raw material is inexhaustible. If magnesium chloride produced in the evaporation of brine for the extraction of salt and bromine is not obtained in sufficient quantity to meet all needs, there are large deposits of magnesite, the magnesium carbonate, in California, Washington, and other States and in Canada. Furthermore, this country has extensive deposits of dolomite, the calcium-magnesium carbonate, in readily accessible and easily quarried beds in the Eastern States, and the oceans themselves may be considered as reserve sources of magnesium.

GOLD, SILVER, COPPER, AND LEAD IN SOUTH DAKOTA.

(MINES REPORT.)

By CHARLES W. HENDERSON.

PRODUCTION.

The total value of the gold, silver, copper, and lead produced at mines in South Dakota in 1917 was $7,526,905, a decrease of $77,787 from the value in 1916. The output of gold was 356,244.77 fine ounces, valued at $7,364,233 almost 98 per cent of the total value. The decrease in the output of gold for the year was 4,663.88 fine ounces in quantity and $96,411 in value. The production of silver decreased from 215,205 fine ounces to 186,765 fine ounces but the value increased from $141,605 to $153,894. Smelting ore shipped from South Dakota carried 10,707 pounds of copper and 68,081 pounds of lead. The output of placer gold was 44.70 fine ounces. There were 30 producing mines of which 23 were deep and 7 were placer, a decrease of 6 deep and 9 placer mines as compared with 1916.

The total quantity of ore mined and treated in 1917 was 1,868,310 short tons, averaging in recovered gold 0.1907 ounce or $3.94 per ton as compared with 1,870,783 short tons averaging $3.99 per ton in 1916. The mills of the State treated 1,867,583 tons of ore, which yielded as bullion $7,350,460 in gold and 181,051 fine ounces of silver, valued at $149,186, an average recovery per ton of $3.94 in gold and 0.10 ounce in silver, as compared with $3.98 in gold and 0.11 ounce in silver in 1916. The crude ore shipped to smelters amounted to 727 tons, having an average content per ton of 0.855 fine ounce of gold, valued at $17.67, and of 7.85 ounces in silver.

Gold and silver bullion produced at mills in South Dakota in 1917.

Process.	Ore treated.	Gold in bullion.	Silver in bullion.
	Short tons.	*Fine ounces.*	*Fine ounces.*
Amalgamation	1,677,623	228,018.51	61,759
Cyanidation	[a]1,809,417	127,560.01	119,292
	....	355,578.52	181,051

[a] Includes 1,619,457 tons of tailings from part of ore amalgamated.

In 1917 the mines in South Dakota consumed 13,199 pounds of quicksilver and 384,938 pounds of sodium cyanide, equivalent to 1 pound of quicksilver for every 17.28 ounces of gold or every 127 tons of ore treated, and 0.21 pound of sodium cyanide for every ton of ore or tailings treated and 0.33 ounce of gold for every pound of cyanide used.

Mine production of gold, silver, copper, and lead in South Dakota in 1916 and 1917.

Year.	Number of mines producing.	Ore.	Gold.[a]		Silver.[a]	
			Quantity.	Value.	Quantity.	Value.
		Short tons.	*Fine ozs.*		*Fine ozs.*	
1916	45	1,870,783	360,908.65	$7,460,644	215,205	$141,605
1917	30	1,868,310	356,244.77	7,364,233	186,765	153,894
Increase or decrease	−15	−2,473	−4,663.88	−96,411	−28,440	+12,289

Year.	Number of mines producing.	Copper.		Lead.		Total value.
		Quantity.	Value.	Quantity.	Value.	
		Pounds.		*Pounds.*		
1916	45	....	....	35,406	$2,443	$7,604,692
1917	30	10,707	$2,923	68,081	5,855	7,526,905
Increase or decrease	−15	+10,707	+2,923	+32,675	+3,412	−77,787

[a] Includes placer production.

Mine production of gold and silver in South Dakota, 1876–1917.[a]

Period.	Gold.	Silver.		Total value (commercial).
		Quantity.	Commercial value.	
		Fine ounces.		
1876–1880	$11,255,843	80,292	$92,452	$11,348,295
1881–1890	30,800,000	1,472,580	1,515,224	32,315,224
1891–1900	48,005,555	1,729,873	1,155,691	49,161,246
1901–1910	65,242,196	1,790,365	1,013,349	66,255,545
1911	7,439,874	203,755	107,990	7,547,864
1912	7,891,370	206,460	126,973	8,018,343
1913	7,319,294	172,702	104,312	7,423,606
1914	7,333,508	176,642	97,683	7,431,191
1915	7,406,305	199,864	101,331	7,507,636
1916	7,460,644	215,205	141,605	7,602,249
1917	7,364,233	186,765	153,894	7,518,127
	207,518,822	6,434,503	4,610,504	212,129,326

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 240, 1914.

Mine production of gold and silver in South Dakota in 1917.

Source.	Number of mines.	Ore.	Gold.		Silver.		Total value.
			Quantity.	Value.	Quantity.	Value.	
					Fine ounces.		
Deep mines:		*Short tons.*	*Fine ounces.*				
Siliceous ore	16	1,867,859	356,168.17	$7,362,650	182,023	$149,987	$7,512,637
Lead ore	5	369	31.05	641	4,608	3,797	4,438
Copper ore	2	82	.85	18	130	107	125
	23	1,868,310	356,200.07	7,363,309	186,761	153,891	7,517,200
Placer mines	7	....	44.70	924	4	3	927
	30	1,868,310	356,244.77	7,364,233	186,765	153,894	7,518,127

MINING INDUSTRY.

GENERAL CONDITIONS.

The Homestake mines and mills were operated without interruption in 1917. The shaft on the Oro Hondo mine, adjoining the Homestake property, was sunk from 2,000 feet to 2,200 feet and considerable drifting and diamond drilling was done. The Golden Reward mill was operated steadily on siliceous ores obtained from its own mines. The Mogul mill was operated steadily, chiefly on custom ore. The Trojan mill was operated continuously on company and custom ore. The Bismarck mine and mill were operated for a short period. The Wasp No. 2 Co. did not operate its mine or mill during the year and the mill has been dismantled. The New Reliance mine and mill were idle. The Deadwood-Standard mill was operated on ore from the Elk Mountain mines during part of the year.

The Rattlesnake Jack mine, in the Galena district, was idle, but considerable lead-silver ore was shipped from the district.

A small output of placer gold was made in Lawrence and Pennington counties. Small shipments of copper ore were made from the Keystone and Rochford district and of gold ore from the Keystone district.

A small shipment of lead ore was made from the Spokane mine, near Custer.

REDUCTION MILLS.

Reduction mills in operation in South Dakota in 1917, by counties.[a]

[A, active; B, building; I, idle.]

Name.	Location.	Process.	Equipment.	Approximate daily maximum capacity.
Custer County:				*Short tons.*
Ruberta (I)	Custer	Amalgamation and cyanidation.	10 stamps, plates, cyanide annex, 2 percolation tanks.	25
Ruby (I)	do	Amalgamation and concentration.	Gates crusher, 10 stamps, 2 Frue vanners, 2 concentrating tables.	30
Spokane (B)	do	Concentration	Rolls, ball mill, jigs, tables, slime tables.	100
Lawrence County:				
Custer Peake	Roubaix	do	10 stamps, Hartz jigs, 4 Wilfley tables.	40
Deadwood-Standard (A).	Cyanide	Cyanidation	1 Gates No. 4 crusher, 2 roller mills, 4 tanks.	100
Deadwood Zinc and Lead (B).	Deadwood	Concentration	10 stamps, 4 tables	40
Golden Reward[b] (A).	do	Cyanidation	1 Gates crusher, 2 Chilean mills, 3 Akins classifiers, 6 Dorr thickeners; 12 tanks (6 percolation, 6 agitation), 1 Portland filter.	200
Golden Reward Roaster (A).[c]	Terry		Wedge roaster	75
Puritan (I)	(Strawberry Gulch).	Cyanidation	20 stamps, 2 Dorr classifiers, tanks.	100
Branch Mint (I)	Galena	do	120 stamps	400
Clover Leaf (I)	do	Amalgamation	60 stamps, plate amalgamation	240

[a] U. S. Geol. Survey Mineral Resources, 1913, pt. 1, pp. 43–45, contains a complete list of reduction mills in South Dakota in that year, with a description of equipment and process. See Parmelee, H. C., Cyanide practice in the Black Hills, S. Dak.: Met. and Chem. Eng., July, 1913, pp. 395–398; August, 1913, pp. 435–438; September, 1913, pp. 500–502.

[b] For description, see Min. and Eng. World, June 7, 1913, pp. 1103–1104.

[c] For description, see Willard, C. G., The Golden Reward roaster; South Dakota School of Mines Pahasapa Quart., June, 1916, pp. 40–45.

Reduction mills in operation in South Dakota in 1917, by counties—Continued.

Name.	Location.	Process.	Equipment.	Approximate daily maximum capacity.
Lawrence County—continued.				*Short tons.*
Gilt Edge (I)	Galena	Concentration	1 Gates crusher, McFarlane rolls, cone classifiers, 2 Monell slimers, 12 Monell concentrating tables.	150
Golden Crest (I)	do	Cyanidation	Blake crusher, 40 stamps, 2 Dorr classifiers, Abbe tube mill, 4 tanks, Moore filter.	250
Rattlesnake Jack (I).	do	Cyanidation and concentration.	10 stamps, Hardinge rolls, tanks, Oliver filter, 2 Wilfley tables.	50
Homestake (A)[a]	Lead	Amalgamation and cyanidation.	6 wet-crushing stamp mills aggregating 1,020 stamps, 20 Gates crushers, 3 tube mills, 131 cone, 37 gravity, and 5 Dorr classifiers; 2 cyanide sand plants (capacity, 75,000 tons per month), 1 cyanide slime plant (capacity 55,000 tons per month), 25 percolation tanks, 12 Dorr thickeners, 25 percolation tanks, 31 Merrill filters.	4,200
Do	do	Tungsten concentration.	5 stamps, 2 dewatering cones, 1 Wilfley, 3 slime tables.	20
Minnesota (I)	Maitland	Cyanidation	1 Austin crusher, 2 roughing rolls, 2 slow-speed Chilean mills, 19 tanks.	200
North Homestake (I).	do	do	40 stamps, cone classifiers, 8 slime and 6 sand tanks, cyanidation by agitation and percolation.	150
Safe Investment (I).	Novak	Cyanidation and concentration.	40 stamps, concentrating tables, cyanide annex.	200
Mogul (A)	Terry	Cyanidation	Gyratory crusher, 2 Trent Chilean mills, 1 Abbe tube mill, 2 Dorr classifiers, continuous decantation and counter current treatment of slime, using 4 Dorr thickeners; 1 Portland filter.	150
Victoria (I)	Portland	do	2 Gates crushers, Davis rolls, Allis-Chalmers rolls, trommels, 5 tanks, dry-crushing and leaching.	200
Lundberg, Dorr & Wilson (I).	Terry	do	Chilean mill, No. 4 Gates crusher, 1 Dorr classifier, 1 Dorr thickener, 4 sand tanks (110 tons); 4 percolation, 1 agitation tank Moore process.	100
New Reliance	Trojan	do	1 Gates crusher, 30 stamps, 1 Dorr classifier, 4 Dorr thickeners, slime tanks, Portland filter.	120
Trojan (A)	do	do	1 Gates No. 5-K crusher, two 7-foot Chilean mills, 1 Ball mill, 3 Dorr classifiers, 1 Weigand classifier, 5 Dorr thickener tanks, 5 agitation tanks, 6 percolation tanks, 3 Portland filters.	400
Bismarck (A)[c]	Yellow Creek (Flat Iron).	do	1 (5-K) and 2 (3-D) Gates crushers, 2 sets rolls, 6 tanks, dry crushing and leaching.	200
Wasp No. 2 (I)[d]	do	do	Steam shovel for stripping, 4 Gates crushers, 4 McFarlane rolls, 6 percolation tanks. Dismantled.	500

[a] Clark, A. J., and Sharwood, W. J., Metallurgy of the Homestake ores: Inst. Min. and Met. Bull. 98, Nov. 14, 1912. Abstracted, Eng. and Min. Jour., Jan. 18, 1913, pp. 161-166, and Jan. 25, 1913, pp. 215-219; also Min. and Emg. World, Dec. 7, 1912, pp. 1035-1039, and Dec. 14, 1912, pp. 1090-1094, and Dec. 21, 1912, pp. 1142-1147, and Dec. 28, 1912, pp. 1189-1192; also Min. and Sci. Press, Jan. 11, 1913, p. 108; also Met. and Chem. Eng., January, 1913, p. 50. Clark, A. J., Notes on Homestake metallurgy; Am. Inst. Min. Eng. Bull. 103, July, 1915, pp. 1381-1400; also Min. and Sci. Press, July 17, 1915, pp. 87-91, and Min. and Eng. World, July 10, 1915, pp. 49-53. Sharwood, W. J., Loss of quicksilver in gold mills: Min. and Sci. Press, Apr. 6, 1918, pp. 483-484.

[b] For description, see Min. and Eng. World, Sept. 28, 1912, p. 571.

[c] For description, see Min. and Sci. Press, Feb. 22, 1913, p. 320.

[d] For description, see Min. and Eng. World, Jan. 4, 1913, p. 11; May 3, 1913, p. 849.

Reduction mills in operation in South Dakota in 1917, by counties—Continued.

Name.	Location.	Process.	Equipment.	Approximate daily maximum capacity.
Pennington County:				*Short tons.*
Black Tom (I)	Castle Creek	Amalgamation	2 crushers, 10 stamps, plates	20
Inca (I)	do	Amalgamation and concentration.	10 stamps, 2 Wilfley tables	30
Hymalufu (I)	do	Amalgamation	2 stamps	15
James G. Blaine (I).	do	do	Chilean mill	2
Golden Summit (I).	Hill City	do	1 Blake crusher, 10 stamps, plates.	30
Slipper (I)	do	do	5 stamps, plates	15
Lisbon (I) (Blue Bird)	Keystone			
Otho (I)	do	Amalgamation and concentration.	3 crushers, 3 Chilean mills, 3 roller mills, 6 Wilfley tables, Frue vanners.	100
Holy Terror (I)	do	Amalgamation, concentration, cyanidation.	1 20-stamp concentration mill, 1 15-stamp concentration mill, 1 cyanide mill (bad state of repair).	80
Clara Belle	Oreville	Amalgamation and cyanidation.	10 stamps, plates, tanks	50
Cochran (I)	Rochford	Amalgamation	Huntington mill	20
Gold King (I) (Cordelia).	do	do	1 crusher, 10 stamps, plates	40
Golden West (I)	do	do	Chilean mill, amalgamating plates.	50
North Star (I)	do	do	25-ton Chilean mill, amalgamation plates.	25
Stanby (I)	do	do	3 Blake crushers, formerly 60 stamps (out of repair).	(?)
Home Lode (Silver City (I).	Rapid Creek	Amalgamation and concentration.	1 crusher, 1 Chilean mill, 2 Simplex sand tables, 2 Simplex slime tables.	30

REVIEW BY COUNTIES.

CUSTER COUNTY.

During the year the Spokane mine, between Custer and Keystone, was reopened and shipped several cars of lead ore. A 100-ton concentrating plant was under construction at this mine.

LAWRENCE COUNTY.[a]

Mine production of gold, silver, copper, and lead in Lawrence County, S. Dak., 1904–1917.

Year.	Number of mines producing.	Ore.	Gold.[b]	Silver.[b]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	44	1,801,524	$7,346,986	161,216			$7,439,282
1905	19	1,826,177	6,955,690	182,597			7,065,979
1906	27	1,771,377	6,816,196	150,537		22,719	6,918,351
1907	22	1,470,154	4,134,667	93,830			4,196,595
1908	17	1,927,844	7,650,523	248,686		23,046	7,783,295
1909	17	1,699,260	6,561,628	191,044	3,977	1,512	6,661,553
1910	19	1,522,986	5,380,795	118,716		14,136	5,445,523
1911	16	1,940,719	7,408,356	203,350		64,311	7,519,025
1912	19	1,901,310	7,875,401	206,356		22,845	8,003,338
1913	20	1,899,162	7,317,320	172,688	290	10,205	7,422,117
1914	21	2,019,016	7,331,638	176,585		2,766	7,429,397
1915	25	1,889,970	7,405,552	199,797			7,506,849
1916	29	1,870,572	7,455,136	215,127		35,406	7,599,127
1917	24	1,868,143	7,360,266	186,436	736	60,905	7,519,328
Increase or decrease	−5	−2,429	−94,870	−28,691	+736	+25,499	−79,799

[a] For information on the geology of this county see Irving, J. D., Ore deposits of the northern Black Hills: U. S. Geol. Survey Bull. 225, pp. 123–140, 1904. Irving, J. D., and Emmons, S. F., Economic resources of northern Black Hills: U. S. Geol. Survey Prof. Paper 26, pp. 53–212, 1904.

[b] Includes both placer and deep mines.

The following table shows the total ore milled, the value of the product, and the dividends paid from 1875 to 1917 by the companies now consolidated in the Homestake Mining Co. The production for 1916 and 1917 is that reported by Blackstone.[1]

Production of Homestake mine, 1875–1917.

	Ore milled.	Value of product.	Value per ton.	Dividends.
	Short tons.			
Homestake Mining Co., to May 31, 1900	....	$31,204,685.28	....	$8,668,750.00
Highland Mining Co., to May 31, 1900	....	13,359,398.95	....	3,834,717.69
Caledonia Gold Mining Co., to May 31, 1900	....	2,341,130.92	....	192,000.00
Deadwood-Terra Mining Co., to May 31, 1900	....	9,001,002.61	....	1,350,000.00
Deadwood Mining Co., to May 31, 1900	....	834,192.28	....	275,000.00
Father de Smet Mining Co., to May 31, 1900	....	3,421,199.01	....	1,125,000.00
Gopher Mining Co., to May 31, 1900	....	71,140.41	....	....
Clara Consolidated Mining Co., to May 31, 1900	....	13,590.56	....	....
Total to June 1, 1900	....	60,246,340.02	....	15,445,467.69
Homestake Mining Co.:				
June 1, 1900, to June 1, 1901	....	3,639,232.03	....	1,260,000.00
June 1, 1901, to June 1, 1902	....	4,303,977.57	....	1,260,000.00
June 1, 1902, to June 1, 1903	....	4,526,942.04	....	819,000.00
June 1, 1903, to June 1, 1904	....	4,800,558.48	....	655.200.00
June 1, 1904, to June 1, 1905	....	5,221,089.30	....	819,000.00
June 1, 1905, to June 1, 1906	....	5,100,445.49	....	1,310,400.00
June 1, 1906, to June 1, 1907	....	4,541,096.07	....	1,201,200.00
June 1, 1907, to June 1, 1908	....	4,717,746.20	....	546,000.00
June 1, 1908, to June 1, 1909	....	5,725,046.67	....	1,365,000.00
June 1, 1909, to June 1, 1910	1,237,331	4,498,751.11	$3.6357	982,800.00
June 1, 1910, to June 1, 1911	1,468,263	5,251,453.75	3.5766	1,310,400.00
June 1, 1911, to Dec. 31, 1911	888,057	3,661,151.60	4.1205	764,400 00
Calendar year 1912	1,528,923	6,600,953.12	4.3174	1,310,400.00
Calendar year 1913	1,540,961	6,186,651.78	4.0148	2,146,224.60
Calendar year 1914	1,587,774	6,160,160.59	3.8798	2,210,208.00
Calendar year 1915	1,573,822	6,428,786.56	4.0848	2,210,208.00
Calendar year 1916	1,600,220	6,531,003.34	4.0813	2,210,208.00
Calendar year 1917	1,677,623	6,619,573.94	3.9458	1,959,048.00
Grand total	....	154,760,959.66	....	39,785,164.29

The Homestake Co.'s public report for the calendar year 1917 shows that during the year 1917 the Homestake mine and its reduction works have been operated without interruption. The tungsten mine kept the concentrating mill supplied with profitable ore during the year, and the outlook is encouraging for another year's supply. The big Nordberg hoist, with its skips, has been in satisfactory operation during the most of the year and has demonstrated that it can easily handle all the ore required for the Hometake mills. Loading pockets are in operation at the 800-foot, 1,100-foot, and 1,550-foot levels. A system of ventilating the lower levels by electrically driven fans is now under construction.

During the year 11,075 feet of development drifts, 2,349 feet of development raises, and 5,896 feet of prospecting drifts were driven. The engineers report that 1,919,177 tons of ore were broken down and now remain in the stopes and that a large supply of profitable ore is blocked out in the mine and is readily accessible for continuous excavation.

An electric drive has replaced the high-pressure air compressor installed for haulage and is running very satisfactorily. The Hanna steam pumps have been replaced by electrically driven turbine pumps.

A second water-power plant was built on Spearfish Creek during the year and is now in successful operation.

---

[1] Blackstone, Richard, A history of the Homestake mine, S. Dak.: Min. and Eng. World, July 15, 1916, pp. 99–102; South Dakota School of Mines Pahasapa Quart., June, 1916, pp. 16–30.

Every department of the Homestake's plant is reported to be in first-class condition for continuous operation and output.

In addition to gold and silver, the Homestake Co. sold tungsten ores, for which it received $226,535.

The Oro Hondo shaft, adjoining the Homestake property, was sunk from 2,000 to 2,200 feet and much diamond drilling and drifting was done.

The mines of the Golden Reward group in the Bald Mountain area and the Portland district were operated throughout the year and shipped oxidized ore to the mill at Deadwood. The roasting plant of this company at the Astoria shaft, previously used for a preliminary roast for the unoxidized ore, was idle. The Mogul cyanidation mill, at Terry, was operated chiefly on custom ore shipped from the mines of the Ofer Co.

The capacity of the Trojan mill was materially increased and it was used to treat much custom ore in addition to ore from the company's mines. Small shipments of unoxidized ores were made direct to smelters from the Golden Reward mines and from the Trojan mine. The new Reliance mine and mill were idle. The Elk Mountain mine was operated for a period, the ore being treated at the Deadwood-Standard mill. Other producing mines were the Crown Hill, Decorah, Gold Dollar, and Two Johns.

In the Bear Butte district shipments of lead ore were made from the General Merritt No. 2, General Merritt No. 1, St. Anthony, and New Silver Queen mines. The 50-ton mill on the Rattlesnake Jack mine was not operated.

In the Custer Peake district only development work was done.

In the Maitland district shipments were made from the Republic mine to the Trojan mill. In the Two-Bit district shipments were made from the Heidelberg mine and from the Monarch mine.

In the Yellow Creek area, the Wasp No. 2 mine and mill were idle, and early in 1917 the mill was dismantled. The Bismarck mine and mill were operated for a period.

In the Rawlings district, near Tinton, a reduced yield of placer gold was made from several placers located chiefly in Bear Gulch and Potato Creek.

PENNINGTON COUNTY.

Mine production of gold, silver, copper, and lead in Pennington County, S. Dak., 1904–1917.

Year.	Number of mines producing.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	16	1,511	$10,500	274	....	....	$10,657
1905	8	11,218	33,096	149	....	....	33,186
1906	6	9,281	24,586	335	....	....	24,810
1907	7	969	3,190	62	....	....	3,231
1908	8	1,235	5,320	72	....	....	5,358
1909	13	4,481	14,897	3,208	114,408	....	31,438
1910	7	943	21,462	84	....	....	21,508
1911	16	5,408	31,209	401	....	....	31,422
1912	16	341	14,782	101	....	....	14,844
1913	5	....	1,780	13	....	....	1,788
1914	8	229	1,664	52	....	1,131	1,737
1915	10	....	344	2	....	....	345
1916	6	211	5,391	78	....	....	5,442
1917	5	146	3,963	147	9,971	....	4,084
Increase or decrease...	−1	−65	−1,428	+69	+9,971	....	−1,358

[a] Includes both deep and placer mines.

A car of copper ore was shipped from the Maloney Blue Lead mine, near Hill City, and from the property of the Black Hills Copper Co., at Rockford. Several cars of gold ore were shipped from the Columbia mine, near Keystone.

A small quantity of placer gold was recovered from Battle and Rapid creeks.

GOLD, SILVER, AND COPPER IN WYOMING.

(MINES REPORT.)

By Charles W. Henderson.

PRODUCTION.

The total value of the gold, silver, and copper produced at mines in Wyoming in 1917 was $560,181, as compared with $666,414 in 1916. The copper alone was valued at $553,605. There were 17 producing mines, of which 16 were deep and 1 placer, a decrease of 8 deep and 3 placer, as compared with 1916. The quantity of ore sold or treated was 6,335 tons, as compared with 8,876 tons in 1916. The deep mines yielded $3,728 in gold, 3,415 ounces of silver, and 2,027,857 pounds of copper. The placer gold produced amounted to only $34, in 1917, as against $349 in 1916.

Mine production of gold, silver, and copper in Wyoming, 1916 and 1917.

Year.	Ore.	Gold.[a]		Silver.[a]		Copper.		Total value.
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Short tons.	*Fine ounces.*		*Fine ounces.*		*Pounds.*		
1916	8,876	994.88	$20,566	5,524	$3,635	2,610,622	$642,213	$666,414
1917	6,335	181.98	3,762	3,415	2,814	2,027,857	553,605	560,181
Decrease	2,541	812.90	16,804	2,109	821	582,765	88,608	106,233

[a] Includes placer gold and silver.

Mine production of gold, silver, and copper in Wyoming, 1842–1917.[a]

Period.	Gold.	Silver.		Copper.		Total value.
	Value.	Quantity.	Commercial value.	Quantity.	Value.	
		Fine ounces.		*Pounds.*		
1842–1867	(b)	....	....	....	....	....
1867–1870	$396,100	3,170	$4,098	....	....	$400,198
1871–1880	400,000	3,240	4,115	....	....	404,115
1881–1890	67,500	2,940	3,126	1,395,287	$230,521	301,147
1891–1900	131,700	1,400	943	7,541,647	1,257,649	1,390,292
1901–1910	130,259	45,983	26,896	16,906,466	2,579,095	2,736,250
1911	19,200	725	384	130,499	16,312	35,896
1912	22,235	265	163	25,080	4,138	26,536
1913	24,184	957	578	385,239	59,712	84,474
1914	5,006	116	64	17,421	2,317	7,387
1915	14,592	840	426	447,246	78,268	93,286
1916	20,566	5,524	3,635	2,610,622	642,213	666,414
1917	3,762	3,415	2,814	2,027,857	553,605	560,181
	1,235,104	68,575	47,242	31,487,364	5,423,830	6,706,176

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 925, 1913.

[b] Small; unknown.

Mine production of gold and silver in Wyoming, 1916 and 1917.

Source.	Number of mines.	Ore.	Gold.		Silve		Total value.
			Quantity.	Value.	Quantity.	Value.	
		Short tons.	*Fine ounces.*		*Fine ounces.*		
Deep mines, 1917:							
Siliceous ore	2	49	92.30	$1,908	33	$27	$1,935
Copper ore	14	6,286	88.04	1,820	3,382	2,787	4,607
Total deep mines:							
1916	24	8,876	978.00	20,217	5,523	3,634	23,851
1917	16	6,335	180.34	3,728	3,415	2,814	6,542
Decrease	8	2,541	797.66	16,489	2,108	820	17,309
Placer mines, 1916	4	....	16.88	349	1	1	350
Placer mines, 1917	1	....	1.64	34	....	....	34
Decrease	3	....	15.24	315	1	1	316
Total deep and placer mines, 1917.	17	6,335	181.98	3,762	3,415	2,814	6,576

REDUCTION MILLS.

Reduction mills in Wyoming in 1917.

[I, idle; B, building; E, experimental; C, clean-up.]

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
				Short tons.
Albany County:				
Rambler (I)	Douglas Creek.	Concentration	1 crusher, 3 rolls, 5 Wilfley and 1 Deister tables, home-construction classifiers.	75
Fram (I)	Centennial	Amalgamation and concentration.	3 stamps, 1 concentrating table	12
Snowy Range (I).	do	Amalgamation	1 Chilean mill	5
Gould (B)	do	Amalgamation and cyanidation.	1 crusher, 2 rolls, 1 tube mill, 6 tanks, roaster.	50
Carbon County:				
Penn Wyoming[a] (I).	Encampment.	Concentration	Blake crusher, elevator, revolving screens, roughing rolls, 2 Hancock jigs, capacity 700 tons per day, rolls, 12 No. 5 Wilfley tables, and slime treatment equipment. Idle for many years.	1,000
Penn-Seminole	Seminole	Amalgamation	20 stamps, amalgamating plates	80
Crook County:				
Reuter (I)	Bear Lodge	Cyanidation	5-foot Huntington mill, 10 by 5 feet percolation tank, 2 Gates crushers.	30
Bock (E)	do	Amalgamation and cyanidation.	1 Gates crusher, 10 stamps, amalgamating plates, tanks.	30
Fremont County:				
Duncan[b] (I) (Beck).	Atlantic City	do	1 Blake crusher, 4 Nissen crushers, 1 Akins classifier, 2 cone classifiers, 5-foot Wheeler type pan tube mill, 4 cyanidation tanks, 3 Dorr thickeners, cyanidation by agitation and decantation, 1 mechanical agitation tank, 1 sand filter tank.	30
Barr (I)	do	Amalgamation	5-foot Huntington mill, 10 stamps.	25
Carissa (C) (Federal).	do	Amalgamation and concentration.	Crusher, 10 stamps 850 pounds each, 1 Frue vanner.	25
Mary Ellen (I)	do	Amalgamation	Denver quartz mill	25
Miners Delight (I).	do	Amalgamation and concentration.	10 stamps, tables	25
Timbah Bah[b] (Dexter) (I).	do	Amalgamation and cyanidation.	Stamps, plates, Dorr classifiers, 6 tanks.	100
Johnson County:				
Onion Creek (I)	Buffalo	Amalgamation	5 stamps, plates, Pierce rifles	10

---

[a] Beeler, H. C., Mineral resources of Wyoming, p. 23, Wyoming State Board of Immigration, 1907.

[b] Trumbull, L. W., Atlantic City gold mining district, Fremont County, Wyo.: Wyoming State Geologist Bull. 7, ser. B, 1914.

MINING INDUSTRY.

The Hartville district, Platte County, with shipments slightly in excess of material shipped in 1916 in weight of ore but of lower content of copper, maintained its place as the principal producing district in Wyoming in 1917. The increased shipments of copper-platinum-palladium ore from the Rambler property, at Holmes, Albany County, made that district the second most important in Wyoming. Various shipments of copper-bearing material from the Encampment district, Carbon County (long idle) contributed an appreciable quantity of copper to the State's output. Reopening of properties in the Copper Mountain district, Fremont County, resulted in shipments of copper ore from the Williams-Luman and the McGrath mines. Small shipments of copper ore were made from the Muskrat Creek (or Manville) district, Goshen County; a car of copper ore was shipped from the Cokeville district, Lincoln County; and one car of copper ore from Tie Siding, Albany County. Small shipments of gold ore and of placer gold bullion were made from the Atlantic City district, Fremont County.

REVIEW BY COUNTIES.[1]

ALBANY COUNTY.[2]

At the Rambler mine, near Holmes, operations were continuous in opening old caved ground and blocking out ore. A considerably increased quantity of ore containing platinum, palladium, copper, silver, and gold was shipped during the year to eastern refineries. The mine is opened by a 180-foot vertical shaft and 5,000 feet of drifts and crosscuts. There is a 50-ton concentration mill on the property, abandoned for the present as unsuitable for the treatment of the ore now being mined.

A car of copper ore was shipped from the Copper King mine, near Tie Siding.

Some development work was done in the Centennial district. A 50-ton mill was built by the Gould Mining & Leasing Co.

BIG HORN COUNTY.[3]

No mining was done in the county in 1917.

CARBON COUNTY.[4]

Some development work was done at the Elkhorn mine in the Elk Mountains district.

The mine and mill on the Penn-Seminole-King group, in the Seminole district, were idle.

---

[1] In this review the footnote references indicate publications containing information on the geology of the respective regions.

[2] Emmons, S. F., Platinum in copper ores in Wyoming: U. S. Geol. Survey Bull. 213, pp. 94–97, 1903. Kemp, J. F., Platinum in the Rambler mine, Wyo.: U. S. Geol. Survey Mineral Resources, 1902, pp. 244–250, 1904. Platinum in Wyoming: Eng. and Min. Jour., Mar. 4, 1911, p. 460. Concentration of platiniferous copper ore at the Rambler mine, Wyo.: Met. and Chem. Eng., February, 1911, pp. 75–78. Spencer, A. C., The Atlantic gold district and the North Laramie Mountains.: U. S. Geol. Survey Bull. 626, pp. 56–77, 1916.

[3] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (No. 141), and Cloud Peak-Fort McKinney folio (No. 142), 1906; Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper 51, 1906. Fisher, C. A. Geology and water resources of Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, 1906.

[4] Spencer, A. C., Mineral resources of the Encampment copper region, Wyo.: U. S. Geol. Survey Bull. 213, pp. 158–162, 1903; also Copper deposits of the Encampment district, Wyo.: U. S. Geol. Survey Prof. Paper 25, 107 pp., 1904. See also Spencer, A. C., Reconnaissance examination of the copper deposits at Pearl, Colo.: U. S. Geol. Survey Bull. 213, pp. 163–169, 1903.

In the Encampment district, several cars of copper-bearing material were shipped from various sources and a car of copper ore was shipped from the Portland Copper Co.'s property.

CONVERSE COUNTY.[1]

No work was done in the North Laramie Peak district nor in the Cottonwood Creek district.

CROOK COUNTY.

Apparently no gold was recovered in the Hurricane district, northwest of Tinton, S. Dak., or if any small quantity were produced, it is included in the Rawlings district, Pennington County, S. Dak., adjoining on the east. In the Bear Lodge district[2] a very small button of gold was yielded in 1917 from the Warren Peak Co.'s mill.

FREMONT COUNTY.

Atlantic City (South Pass) district.[3]—A small shipment of copper ore was made from the Elenor mine, and small shipments of gold ore and gold bullion from the Ben Hur—Lucky Strike property.

Copper Mountain district.—A car of copper ore was shipped from the McGrath mine as a test lot.

Several cars of copper ore were shipped from the Williams-Luman property, reopened in October, 1916, after an idleness of several years.

Gold placers on Wind and Big Horn rivers.[4]—No yield was made from these deposits.

GOSHEN COUNTY.

Two cars of silver-copper ore were shipped from the Muskrat Creek district.

JOHNSON COUNTY.[5]

No work was done in the Big Goose, Bull Camp, and Kelly Creek districts.

LARAMIE COUNTY.

The properties in the Silver Crown district, near Hecla, were idle.

LINCOLN COUNTY.[6]

A car of silver-copper ore was shipped from Cokeville.

NATRONA COUNTY.

Assessment work was done on the Nettie M. mine, in the Casper Mountain district, 10 miles south of Casper.

---

[1] Spencer, op. cit. pp. 66-71, 80-81.

[2] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Sundance folio (127), 1905.

[3] Trumbull, L. W., Atlantic City gold mining district, Fremont County, Wyo.: Wyoming State Geologist Bull. 7, ser. B, 1914. Spencer, A. C., The Atlantic gold district and the North Laramie Mountains: U. S. Geol. Survey Bull. 626, pp. 1-45, 1916.

[4] Schrader, F. C., Gold placers on Wind and Big Horn rivers, Wyo.: U. S. Geol. Survey Bull. 580, pp. 127-145, 1915.

[5] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (No. 141), and Cloud Peak-Fort McKinney folio (No. 142), 1906; also Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper 51, 1906.

[6] Schultz, A. R., Gold developments in central Uinta County, Wyo., and at other points on Snake River: U. S. Geol. Survey Bull. 315, pp. 71-88, 1907.

PARK COUNTY.

Very little work was done in the Sunlight and Kirwin district.[1]

PLATTE COUNTY.[2]

Shipments of copper-silver ore were continued from the Hartville district[3] in 1917, chiefly from the Sunrise mine, near Sunrise.

SHERIDAN COUNTY.

No work was done on the prospects in the Black Mountain, Wolf Creek, and Tongue River districts.

UINTA COUNTY.[4]

No output has been recorded from Uinta County since 1915. The present Uinta County includes only the southern part of the former Uinta County, the northern part (about four-fifths) having been set off in 1915 as Lincoln County.

---

[1] Hewett, D. F., The ore deposits of Kirwin, Wyo.: U. S. Geol. Survey Bull. 540, pp. 121-132, 1914.

[2] The northwestern part of Laramie County prior to 1913.

[3] Smith, W. S. T., U. S. Geol. Survey Geol. Atlas, Hartville folio (No. 91), 1903. Ball, S. H., Copper deposits of the Hartville uplift, Wyoming: U. S. Geol. Survey Bull. 315, pp. 93-107, 1907.

[4] Schultz, A. R., Gold developments in central Uinta County, Wyo., and at other points on Snake River: U. S. Geol. Survey Bull. 315, pp. 71-88, 1907.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN UTAH.[1]

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

GENERAL STATEMENT.

In 1917 the output of gold, silver, copper, lead, and zinc from Utah mines was valued at $99,328,155, an increase of $10,059,471, compared with 1916. There were 331 lode producers and 3 placers, as against 310 lode producers and 8 placers in 1916. There was increase in the output of ore and in the production of silver and copper, as well as in the value of those metals. Gold decreased from $3,574,947 in 1916 to $3,355,156 in 1917, and silver increased in value from $8,720,498 to $11,106,806. Lead decreased in quantity but increased in value to $15,352,888, or $1,450,073 more than in 1916. The value of recoverable zinc decreased from $3,962,719 to $2,171,261 in 1917, and the placer output of gold decreased from $1,250 in 1916 to $112 in 1917.

Mine production of gold, silver, copper, lead, and zinc in Utah in 1916–17.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	318	13,920,643	$3,574,947	13,253,037	240,275,222	201,490,075	29,572,528	$89,268,684
1917	334	15,358,481	3,365,156	13,479,133	246,674,153	178,521,958	21,286,871	99,328,155
Increase or decrease in 1917	....	+1,437,838	−219,791	+226,096	+6,398,931	−22,968,117	−8,285,657	+10,059,471
1864–1917	....	....	93,119,333	366,020,527	1,962,162,413	3,975,600,157	191,957,609	[b]916,155,337

[a] Includes small placer production.
[b] The total, by years, to the end of 1913, appears in Mineral Resources, 1913, pt. 1, p. 366, 1914.

Since the year 1864 Utah mines have produced gold, silver, copper, lead, and zinc valued at $916,155,337. This includes $93,119,333 in gold, $271,788,824 in silver, $346,681,440 in copper, $188,715,846 in lead, and $15,849,894 in zinc. Dividends paid by 21 producers in

---

[1] The statistical tables in this report were compiled by Bessie N. Patchell, of the United States Geological Survey.

1917 amounted to the sum of $29,471,015. In the history of the State dividends paid to stockholders of mining property, representing more than 85 mines, have amounted to $182,245,816.

ORE.

There were sold or treated in 1917 15,358,481 short tons of ore, containing recoverable metals valued at $99,328,043—an increase of 1,437,838 tons, compared with the production of 1916. The total average value per ton was $6.47 in 1917, against $6.41 in 1916, and the gold and silver value per ton increased from 88 cents to 94 cents. There was an increased quantity of low-grade disseminated copper ore produced in 1917, and many old mine and tailing dumps continued to yield profitable material for the mills and smelters.

The output of dry or siliceous ore increased from 89,363 tons in 1916 to 164,057 tons in 1917. This classification includes 14,728 tons of siliceous gold ores, averaging $6.57 in gold, 3.83 ounces of silver, and 3.92 pounds of copper per ton. Gold and silver mixed ores, dry or siliceous in character, aggregated 25,318 tons and averaged per ton $3.97 in gold, 6.01 ounces of silver, and 40.34 pounds of copper. The siliceous silver ores mined in 1917 by 50 producers amounted to 124,011 tons and averaged per ton $1.81 in gold, 17.19 ounces of silver, 7.90 pounds of copper, and 7.87 pounds of lead, against 83,718 tons produced by 40 operators in 1916, which averaged $1.81 in gold, 13.31 ounces of silver, 16.84 pounds of copper, and 1.81 pounds of lead. The Dragon Consolidated mine in the Tintic district was the heaviest producer of silver ore, followed by the Iron Blossom, Chief Consolidated, and Victoria mines. The Ontario mine, at Park City, was next in importance as a shipper of silver ore. The chloridizing roasting process was operated only in the Tintic district in 1917, and 60,767 tons of siliceous silver ores were directly treated, yielding a base bullion of copper, silver, and gold. This bullion was treated at eastern refineries.

The copper ore mined by 122 producers amounted to 14,121,671 tons, which contained 14 cents in gold and 0.16 ounce of silver per ton, and 0.84 per cent of copper, and averaged $4.83 a ton in value. Comparison with ore of similar character in 1916 shows that the quantity increased 1,445,519 tons, the gold and silver content decreased slightly, and the copper content was nearly the same. Of the copper ore mined, the larger part, or 13,326,810 tons, was from the low-grade disseminated deposits. This ore produced 648,907 tons of copper concentrates, which were smelted. There were 617,156 tons of copper ore smelted directly, of which 447,230 tons were sulphide ore, assaying $1.46 in gold and 1.55 ounces of silver per ton, and 1.91 per cent of copper, and valued in all, per ton, at $13.18; and 169,926 tons were oxidized ore, assaying $1.59 in gold and 5.91 ounces of silver per ton, and 3.29 per cent of copper, valued in all, per ton, at $24.41.

Less lead ore was mined in 1917 than in 1916. The output of 190 producers aggregated 638,071 tons and averaged 88 cents in gold and 11.74 ounces of silver per ton, and 0.49 per cent of copper and 10.75 per cent of lead, and $31.73 in total value per ton. Of this output 446,786 tons of sulphide and oxidized ores in about equal quantities were shipped directly to the smelters, the total quantity averaging

$1.09 in gold and 15.38 ounces of silver per ton, 0.59 per cent of copper and 13.56 per cent of lead, and $40.30 in value per ton. Of the lead ores, 179,907 tons were concentrated, yielding 44,630 tons of lead concentrate averaging $1.63 in gold and 13.73 ounces of silver per ton, and 1.09 per cent of copper and 17.89 per cent of lead, and $49.69 in total value per ton. Lead concentrate from 241,593 tons of lead-zinc ore aggregated 86,260 tons, averaging $4.55 in gold and 12.33 ounces of silver per ton, and 0.67 per cent of copper and 20.51 per cent of lead, and $53.65 in total value per ton.

Zinc ore shipped from 22 properties in 1917 aggregated 6,535 tons, against 18,400 tons from 32 producers in 1916. All the zinc ores produced in 1917 was of smelting grade and averaged 28.04 per cent of recoverable zinc, with a little lead. Of this product 6,404 tons were oxidized or mixed carbonate and silicate ores, averaging 27.96 per cent of recoverable zinc, and 131 tons were sulphide ore, averaging 31.54 per cent of recoverable zinc. Zinc was produced electrolytically from zinc concentrate at the Judge reduction plant near Park City. This plant was still in the experimental stage in 1917. Zinc concentrates saved from lead-zinc ore milled aggregated 14,094 tons and averaged 41 cents in gold and 9.34 ounces of silver per ton, 0.60 per cent of copper, 2.33 per cent of lead, and 32.67 per cent of recoverable zinc. There were also zinc concentrates recovered from tailings averaging 34.69 per cent of recoverable zinc.

There were 27 lead-zinc producers in 1917 who reported 421,704 tons of ore and old tailings re-treated. The ore was milled, making a lead concentrate and a zinc concentrate. The tailings yielded 12,924 tons of lead-zinc concentrates, which averaged 91 cents in gold and 10.37 ounces of silver per ton, and 0.85 per cent of copper, 7.52 per cent of lead, 29.62 per cent of zinc, and $87.46 in value per ton. There were 3,413 tons of lead-zinc ore shipped to smelters, averaging 11.05 per cent of recoverable zinc and 11.74 per cent of lead, valued at $42.90 per ton.

Copper-lead ore, most of it oxidized or carbonates, decreased from 9,645 tons produced by 19 mines in 1916 to 6,443 tons produced by 28 mines in 1917. Of this ore, 6,326 tons was of smelting grade and averaged 25 cents in gold and 14.46 ounces of silver per ton, and 3.05 per cent of copper, and 11.18 per cent of lead, and $48.04 in value per ton. The remainder of the copper-lead product was 117 tons of sorted slag.

Concentrates of all kinds produced in Utah in 1917, including those heretofore mentioned, aggregated 813,287 tons, contained more than 45 per cent of the gold, against more than 40 per cent in 1916; more than 18 per cent of the silver, against nearly 19 per cent in 1916; more than 85 per cent of the copper, against more than 84 per cent; 30 per cent of the lead, about the same as in 1916; and more than 79 per cent of the zinc, against about 60 per cent in 1916. In 1917 the recoverable metal content of the concentrates was valued at $67,283,690, or a total average value per ton of $82.73, as against a total value in 1916 of $59,571,419, or a total average value per ton of $79.50.

Crude ore of all kinds shipped directly to the smelters represented more than 7.67 per cent, or 1,178,002 tons, of the total output and produced nearly 54 per cent of the gold in 1917, as against more than

59 per cent in 1916; nearly 78 per cent of the silver, against nearly 80 per cent; more than 14 per cent of the copper, against more than 15 per cent; nearly 70 per cent of the lead, against nearly 69 per cent; and nearly 21 per cent of the zinc, against nearly 39 per cent in 1916. In 1917 the total value of the crude ore shipped to smelters was $31.344,169, or an average value per ton of $26.61, as against a total value in 1916 of $29,202,373, or an average value per ton of $22.79.

At mills using cyanidation and amalgamation a negligible quantity of gold and silver was recovered from 190 tons of ore. The value of the gold and silver recovered from ore was $2,929, or $15.42 per ton. In 1916 the recovery of gold and silver from ores given similar treatment was valued at $6,613, or an average value per ton of $4.65.

Ore and metals produced in Utah in 1917.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	3	....	$112	....	....	....	....
Dry or siliceous	58	164,057	421,594	2,340,537	2,579,070	976,227	....
Copper	122	14,121,671	1,960,617	2,225,119	235,899,850	14,872	....
Lead	190	638,071	560,527	7,490,650	6,256,268	137,245,961	....
Zinc	22	6,535	....	....	....	60,078	3,664,962
Copper-lead	28	6,443	1,907	93,296	393,079	1,436,782	....
Lead-zinc	27	421,704	410,399	1,329,531	1,545,886	38,788,038	17,621,909
		15,358,481	3,355,156	13,479,133	246,674,153	178,521,958	21,286,871

Ore sold or treated in Utah in 1917, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver	96	239,643	18,894	1,311	253	47,841	308,038
Box Elder	197	10,547	2,064	1,151	....	30	13,989
Cache	....	57	....	....	....	....	57
Emery	....	17	....	....	....	....	17
Garfield	15	9	....	....	....	....	24
Grand	46	40	....	....	....	....	86
Iron	3	....	446	....	....	....	449
Juab	137,365	96,907	128,269	1,540	3	276	364,360
Millard	....	147	31	....	....	....	178
Morgan	....	....	171	....	....	....	171
Piute	75	53	2,000	....	....	....	2,128
Salt Lake	9,545	13,743,334	270,142	9	604	240,046	14,263,680
San Juan	....	28	....	....	....	....	28
Sanpete	....	....	16	....	....	....	16
Summit	12,034	44	87,797	....	....	75,045	174,920
Tooele	263	30,466	93,307	2,149	5,583	280	132,048
Uinta	....	4	1	....	....	....	5
Utah	4,175	51	27,672	375	....	....	32,273
Wasatch	243	....	7,261	....	....	58,186	65,690
Washington	....	324	....	....	....	....	324
	[a] 164,057	14,121,671	638,071	6,535	6,443	421,704	15,358,481
Value per ton in gold and silver	$14.33	$0.27	$10.55	....	$12.23	$3.57	$0.94

[a] Includes 14,728 tons of gold ore, 25,318 tons of gold and silver ore, and 124.011 tons of silver ore.

GOLD.

The mine production of gold reported from all sources by Utah producers in 1917 was $3,355,156—a decrease of $219,791, compared with 1916. The largest part of the gold was contained in ores produced in Salt Lake County and amounted to $2,268,684, against

$2,513,096 in 1916. Juab County ranked next, with $843,609, against $856,474 in 1916. Bingham district produced $2,241,152, and Tintic district $868,547; in 1916 these outputs were, respectively, $2,490,158 and $855,454. Tooele County mines were credited with $32,344, against $18,882 in 1916. Placer gold was produced in Grand and Uinta counties and amounted in value to $112, against $1,250 in 1916. Ores treated in mills equipped for amalgamation produced $2,908 in gold in 1917 from 190 tons of ore mined in Beaver, Box Elder, and Garfield counties. No cyanidation of ore was reported in 1917. The gold extracted by amalgamation averaged $15.31 a ton of ore treated, as against $6.90 a ton treated in 1916. Concentrates of copper, lead, lead-zinc, and zinc, and a small quantity of siliceous concentrate contained altogether $1,522,982 in gold, against $1,433,992 in 1916. Copper concentrates contained the largest quantity of gold, or 50,280.80 ounces, against 47,028.69 ounces in 1916, 37,836.53 ounces in 1915, 35,863.89 ounces in 1914, and 29,699.38 ounces in 1913; the lead concentrates contained 22,522.72 ounces, against 21,875.79 ounces in 1916; and the zinc concentrates 294.14 ounces, against 126.88 ounces in 1916. Lead-zinc concentrates in 1917 produced 571 ounces of gold, against 337.73 ounces in 1916.

A large part of the gold produced in Utah is a by-product of the copper and lead ores. Ranking first in 1917, the Utah Copper property is credited with 51,111.71 ounces. The United States property reported about two-thirds of its output of gold as contained in lead ores and the remainder in copper ores. Next in importance as producers of gold, named in order of production, were the Highland Boy, with 13,530 ounces; the Centennial-Eureka, and the Chief Consolidated, which reported 9,175 ounces.

Mine production of gold in Utah in 1917, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver		3.44	606.88	1,308.48	0.93	272.33	2,192.06
Box Elder		129.74	.20	58.38			188.32
Garfield		12.42	17.24				29.66
Grand	1.69	.87	.24				2.80
Iron		1.94		1.98			3.92
Juab		19,522.28	12,314.75	8,972.17	.39		40,809.59
Millard			18.62				18.62
Piute		138.87	12.91	887.94			1,039.72
Salt Lake		94.98	81,296.87	9,393.32	27.97	18,934.45	109,747.59
Summit		378.28		4,305.44		206.17	4,889.89
Tooele		29.87	537.54	932.73	62.96	1.54	1,564.64
Uinta	3.73						3.73
Utah		79.23	39.60	1,233.64			1,352.47
Wasatch		2.69		21.41		438.56	462.66
	5.42	[a]20,394.61	94,844.85	27,115.49	92.25	19,853.05	162,305.67

[a] Includes 4,678.60 ounces from gold ore, 4,864.68 ounces from gold and silver ore, and 10,851.33 ounces from silver ore.

SILVER.

The mine production of silver in Utah in 1917 was 13,479,133 ounces, valued at $11,106,806, an increase of 226,096 ounces in quantity and of $2,386,308 in value. The largest production was from Juab County, credited with 4,988,005 ounces, against 4,892,439 ounces in 1916. Salt Lake County had the next largest output, 3,769,884 ounces in 1917, against 3,863,264 ounces in 1916. The Bingham district in Salt Lake County produced 2,786,120 ounces, or more than 73 per cent of the county total; Tintic district, in Juab and Utah counties, 5,558,763 ounces, and the Park City region, in Summit and Wasatch counties, 2,937,438 ounces. Concentrates produced at milling plants yielded 2,469,804 ounces of silver, against 2,473,132 ounces in 1916. The copper ores milled produced 525,923 ounces, against 488,742 ounces in 1916, 412,745 ounces in 1915, 358,486 ounces in 1914, and 324,586 ounces in 1913. Lead concentrates from low-grade lead ore contained 1,675,899 ounces of silver, or an average per ton of 12.80 ounces, against 1,792,713 ounces, or an average of 10.87 ounces, in 1916; zinc concentrates contained 9.34 ounces per ton, against 4.61 ounces per ton in 1916. The lead-zinc concentrate contained 10.37 ounces per ton in 1917.

The silver content of bullion produced from ores treated by amalgamation was 26 ounces, against 146 ounces in 1916. No cyanidation of silver ores was reported in 1917. One mill in Utah, at Silver City, using a chloridizing roast on ores, recovers a rich silver bullion, from which 497,915 ounces were reported in 1917.

Six properties produced more than 500,000 ounces of silver in 1917. The Chief Consolidated, in the Tintic district, ranked first with an output of 1,534,907 ounces, followed by the Silver King Coalition, United States mines, at Bingham, Centennial-Eureka, Utah Copper, and Eagle & Blue Bell mine.

Mine production of silver in Utah in 1917, in fine ounces.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver	1,105	31,962	175,340	3,427	85,999	297,833
Box Elder	1,423	2,607	16,434			20,464
Cache		52				52
Emery		17				17
Garfield	3	36				39
Grand	3,986	706				4,692
Iron	948		493			1,441
Juab	1,532,513	845,897	2,609,480	115		4,988,005
Millard		332	42			374
Morgan			703			703
Piute	909	885	44,946			46,740
Salt Lake	378,215	1,211,092	1,445,595	15,393	719,589	3,769,884
San Juan		113				113
Summit	360,356	228	1,794,045		121,954	2,276,583
Tooele	8,472	130,699	578,138	74,361	1,595	793,265
Uinta		18	2			20
Utah	47,800	431	569,778			618,009
Wasatch	4,807		255,654		400,394	660,855
Washington		44				44
	[a]2,340,437	2,225,119	7,490,650	93,296	1,329,531	13,479,133

[a] Includes 56,383 ounces from gold ore, 152,231 ounces from gold and silver ore, and 2,131,923 ounces from silver ore.

COPPER.

The production of copper in 1917 in Utah was 246,674,153 pounds, valued at $67,342,044—an increase of 6,398,931 pounds in quantity and of $8,234,339 in value. Bingham or West Mountain district produced 225,411,675 pounds of copper in 1917, against 223,619,609 pounds in 1916, 176,593,414 pounds in 1915, 141,924,811 pounds in

1914, 144,920,494 pounds in 1913, 116,621,793 pounds in 1912, and 129,995,865 pounds in 1911; Tintic district produced 9,117,723 pounds in 1917, against 7,106,645 pounds in 1916; Park City region produced 1,285,308 pounds, against 1,512,578 pounds in 1916; Beaver County, 3,702,085 pounds, against 3,203,688 pounds in 1916; and Tooele County, 4,181,231 pounds, against 2,836,678 pounds in 1916.

Concentrates of all kinds produced at Utah milling plants contained 210,127,703 pounds of copper, against 202,854,684 pounds in 1916. Copper concentrates contained 207,603,875 pounds, against 199,997,786 pounds in 1916; lead concentrates, 2,134,184 pounds, against 2,726,091 pounds in 1916; zinc concentrates, 168,483 pounds, against 25,440 pounds in 1916; and lead-zinc concentrates, 219,167 pounds, against 105,367 pounds in 1916. Crude ore shipped to smelters contained 35,688,301 pounds of copper, against 36,830,473 pounds in 1916. The crude copper ore smelted contained 28,282,873 pounds, of which 17,114,351 pounds were from sulphide ores and 11,168,522 pounds were from oxidized ores. Lead ores smelted produced 5,259,363 pounds of copper, the sulphide ores yielding 3,878,101 pounds and the oxidized ores 1,381,262 pounds. Copper-lead ores, which were mostly sulphides, contained 385,688 pounds of copper. The dry or siliceous ores, used principally for fluxing at smelting plants, contained 1,760,377 pounds, against 977,497 pounds in 1916. Copper ore from the low-grade copper-bearing disseminated ores contained 208,768,759 pounds of copper, against 199,996,870 pounds in 1916, 156,040,257 pounds in 1915, 125,777,441 pounds in 1914, 126,364,491 pounds in 1913, and 102,662,335 pounds in 1912. Part of the tailing of the Cactus mill, in Beaver County, was reworked and the output is included above.

The leading producers of copper named in order of production were the Utah Copper Co., reporting 206,174,442 pounds; the Highland Boy, 7,968,165 pounds; and the Ohio Copper Co.

Mine production of copper in Utah in 1917, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver	2,114	3,377,849	250,593	15,556	55,973	3,702,085
Box Elder		1,361,119	222			1,361,341
Cache		4,717				4,717
Emery		6,063				6,063
Garfield		2,749				2,749
Grand	1,667	12,772				14,439
Iron			78			78
Juab	2,530,137	6,217,154	313,103	171		9,060,565
Millard		16,267				16,267
Piute		4,004	14,766			18,770
Salt Lake	27,925	222,800,919	2,796,520	57,693	1,091,333	226,774,390
San Juan		14,918				14,918
Summit	13,406	6,214	708,085		44,416	772,121
Tooele	1,012	1,925,944	1,931,818	319,659	2,798	4,181,231
Uinta		4,098				4,098
Utah	544	5,687	81,527			87,758
Wasatch	2,265		159,556		351,366	513,187
Washington		139,376				139,376
	[a]2,579,070	235,899,850	6,256,268	393,079	1,545,886	246,674,153

[a] Includes 577,971 pounds from gold ore, 1,021,380 pounds from gold and silver ore, and 979,719 pounds from silver ore.

LEAD.

The mine production of lead in Utah in 1917 was 178,521,958 pounds, and was 22,968,117 pounds less than the output of 1916. Bingham or West Mountain district produced 73,523,708 pounds, a decided decrease in 1917 as compared with 85,996,490 pounds in 1916, 80,004,006 pounds in 1915, 76,453,128 pounds in 1914, 71,001,138 pounds in 1913, and 43,822,495 pounds in 1912. The greatest part of the production at Bingham came from the Utah Apex, Utah Metal, Highland Boy, and Dalton & Lark mines. Park City region produced 33,715,565 pounds of lead, against 33,233,794 pounds in 1916. Tintic district produced 35,078,948 pounds, against 39,294,351 pounds in 1916. The combined production of Ophir and Rush Valley districts, in Tooele County, aggregated 12,896,789 pounds, against 18,275,389 pounds in 1916. The output in Beaver County decreased from 5,948,220 pounds in 1916 to 5,321,400 pounds in 1917. Lead contained in total concentrate recovered at milling plants and shipped to smelters amounted to 53,956,225 pounds, against 61,315,355 pounds in 1916. The lead concentrates from lead and lead-zinc ores averaged 19.61 per cent of lead in 1917, against 18.18 per cent in 1916; zinc concentrates contained 655,534 pounds, averaging 2.33 per cent of lead in 1917, against 1.05 per cent in 1916. The total crude ore of shipping grade contained 124,429,731 pounds, against 138,628,633 pounds in 1916. Sulphide lead ore contained 61,284,562 pounds of lead, against 67,837,865 pounds in 1916. The oxidized lead ores carried 59,881,443 pounds, against 67,067,162 pounds in 1916.

Of the zinc ores shipped in 1917, the oxidized ores contained 49,598 pounds of lead and the sulphide ores 10,480 pounds. Of the copper-lead ores, the oxidized or carbonate ores contained 510,242 pounds and the sulphide ores 904,681 pounds of lead.

Ranking first in the output of lead in 1917 was the Utah Apex mine, at Bingham, followed by the Silver King Coalition, Highland Boy, and Chief Consolidated, named in order of production. Each of these was credited with more than 10,000,000 pounds. Those closely following were the Eagle & Blue Bell, Cardiff, and Silver King Consolidated.

Mine production of lead in Utah in 1917, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper- ore.	Lead-zinc ore.	Total.
Beaver	1,220	10,132	4,072,422	11,366	71,299	1,154,961	5,311,400
Box Elder			790,246	40,600		8,437	839,283
Iron			156,243				156,243
Juab	1,392		30,288,586		818	76,790	30,367,586
Millard			8,322				8,322
Morgan			75,400				75,400
Piute			540,476				540,476
Salt Lake	571,151	4,740	56,205,040		126,737	29,956,282	86,863,950
Sanpete			5,814				5.814
Summit	389,871		23,702,318			1,429,585	25,521,774
Tooele	5,854		13,729,845	8,112	1,237,928	49,782	15,031,521
Uinta			1,328				1,328
Utah			5,595,070				5,595,070
Wasatch	6,739		2,074,851			6,112,201	8,193,791
	[a]976,227	14,872	137,245,961	60,078	1,436,782	38,788,038	178,521,958

[a] All from silver ore.

ZINC.

Tintic, North Tintic, Park City, Ophir, Rush Valley, Bingham districts, and Beaver County were important producers of zinc. The total mine production of recoverable zinc in Utah in 1917 was 21,286,871 pounds, valued at $2,171,261, against 29,572,528 pounds, valued at $3,962,719, in 1916. The mines of the Park City region yielded 5,201,756 pounds of recoverable zinc, compared with 5,136,353 pounds in 1916. Most of the production was from the Daly Judge property, and a considerable quantity was derived from the old tailings on the flats below the town. Salt Lake County, with Bingham the principal source, produced 8,826,658 pounds of recoverable zinc, against 11,376,384 pounds in 1916. Beaver County increased its output from 3,969,405 pounds in 1916 to 4,133,464 pounds in 1917. The Promontory district of Box Elder County yielded 574,357 pounds of zinc in 1917, against 2,668,401 pounds in 1916. Tintic district decreased in output from 3,711,156 to 1,182,941 pounds.

Lead-zinc ore and old tailings aggregating 421,704 tons were smelted or milled, of which 3,413 tons of ore were shipped directly to the smelters and 241,593 tons of ore and 176,198 tons of old tailings were concentrated, yielding 86,260 tons of lead concentrate, 14,094 tons of zinc concentrate, and 12,924 tons of lead-zinc concentrate. The old tailings yielded 2,720 tons of lead concentrate, 1,564 tons of zinc concentrate, and all of the lead-zinc concentrate mentioned above. The lead-zinc ore and tailing concentrates shipped to smelting works contained 17,621,909 pounds of recoverable zinc, of which 754,339 pounds were contained in crude lead-zinc ore, 9,210,334 pounds in zinc concentrate, and 7,657,236 pounds in lead-zinc concentrate. The old tailings re-treated at Frisco, Midvale, and Park City yielded 1,564 tons of zinc concentrate containing 1,085,195 pounds of recoverable zinc, and 12,924 tons of lead-zinc concentrate containing 7,657,236 pounds of recoverable zinc.

Most of the last-named product was shipped to the electrolytic zinc plant at Great Falls, Mont. Crude zinc ores and lead-zinc ores smelted contained 4,419,301 pounds of zinc, of which 3,664,962 pounds were derived from zinc ores and 754,339 pounds from lead-zinc ores. In 1917 the oxidized zinc and lead-zinc ores predominated and produced, respectively, 3,582,308 pounds and 146,507 pounds of recoverable zinc, the sulphide zinc ores 82,654 pounds, and the sulphide lead-zinc ore 607,832 pounds.

Leading in the output of zinc in 1917 were the Daly-Judge property, near Park City, and the two tailing mills, at Midvale and Frisco, followed by the Utah Apex and United States mines, at Bingham.

Mine production of recoverable zinc in Utah in 1917, in dry pounds.

County.	Zinc ore.	Lead-zinc ore.	Total.
Beaver	670,760	3,462,704	4,133,464
Box Elder	596,718	12,319	609,037
Juab	897,243	94,833	992,076
Salt Lake	4,721	8,821,937	8,826,658
Summit		1,247,303	1,247,303
Tooele	1,278,614	28,360	1,306,974
Utah	216,906		216,906
Wasatch		3,954,453	3,954,453
	3,664,962	17,621,909	21,286,871

Zinc ore and concentrates produced from Utah mines and mills sold in 1917.

Classification.	County.	Quantity, dry weight.	Average zinc content of ore or concentrates.
		Short tons.	*Per cent.*
Sulphide ore	Beaver and Salt Lake	[a] 3,137	12.95
Mixed carbonate and siliceous ore	Beaver, Box Elder, Juab, Salt Lake, Tooele, and Utah.	6,811	32.20
Concentrates	Beaver, Salt Lake, Summit, Tooele, and Wasatch.	27,018	37.15
		36,966	34.18

[a] All of this ore, chiefly from Bingham and some from Frisco, contained lead and zinc sold to oxide manufacturers in the Eastern States.

METAL-MINING INDUSTRY IN UTAH IN 1917.

Although the Utah mining industry was prosperous throughout 1917, the war conditions were such that many mines were restricted in their output, first by a shortage of railroad cars and afterward by a scarcity of skilled labor. For a part of the year the smelting companies had to refuse the full quantity of ore contracted from the mine operators. Notwithstanding these conditions the quantity of ore mined and the total value of the output in 1917 were greater than in 1916. West Mountain (Bingham), Park City, American Fork, Ophir, the Cottonwood districts, and Beaver County produced continually, except as curtailed by the conditions mentioned. Electric power lines in Utah are continually being extended where most needed. The Wasatch Power Co., owned by the Wasatch Mines Co., supplied all the Cottonwood district with power from its hydroelectric plant in Little Cottonwood Canyon. This company connected its line with a branch line of the Utah Power & Light Co., which was constructed over the divide from the Cardiff mine, in the South Fork of Big Cottonwood Canyon.

The narrow-gage railroad in Little Cottonwood Canyon was completed to the old Columbus mill site, near Alta. Considerable trouble was caused by poor railroad equipment, and not much hauling of ore was done in 1917. This narrow-gage road connects at Wasatch with the Salt Lake & Alta Railroad, which, on September 1, 1917, was taken over by the Denver & Rio Grande Railroad Co., operating the line between Wasatch and Midvale.

In the Deep Creek region the branch line of the Western Pacific, extending 43 miles from Wendover to Gold Hill, was operated continuously and a considerable quantity of ore was carried to the smelters.

METALLURGIC INDUSTRY.

GENERAL STATEMENT.

There was no cyanidation of ores in Utah in 1917. One mill, however, was constructed to use the cyanide process in connection with the flotation process. It is expected to be in operation in 1918. This mill is to treat the ores of the Deer Trail mine, situated near Marysvale. Some gold was reported from the amalgamation of ores mined in Beaver, Box Elder, and Garfield counties. The Susannah property in the Park Valley district of Box Elder County was the largest producer. About 5 pounds of quicksilver is estimated to have been consumed at the amalgamation mills. The output for 1917 from gold and silver mills was derived from 190 short tons of ore from Beaver, Box Elder and Garfield counties, and consisted of 140.66 fine ounces of gold and 26 fine ounces of silver, recovered by amalgamation. The total value was $2,929.

Of the 27 plants operated in 1917 in Utah, 2 were amalgamation plants and 25 were concentration plants. Of the latter, 11 were equipped with tables followed by the oil flotation process and 3 used flotation alone. One plant was equipped for wet concentration followed by magnetic separation. There were 2 leaching plants, of which one, near Park City, used the electrolytic method of recovering zinc from solution and the other plant, at Silver City, gave the ores a chloridizing roast. After leaching, the solutions from this roasted ore were passed over iron scrap and the resulting precipitates were melted into a base bullion containing copper, silver, and gold.

The Midvale Minerals Co., operated a 250-ton flotation plant on tailings from the United States concentrator at Midvale and shipped lead-zinc concentrate, which was sold to the Anaconda Co., at Great Falls, Mont. The Childers Leasing Co., working on a different part of the same tailing dump, also with a flotation plant, produced lead-zinc concentrate, which went to Kansas zinc plants.

At Frisco the old tailings of the Horn Silver mill were treated in the Caldo 150-ton flotation and table concentration mill, producing a lead-zinc concentrate and a lead concentrate containing silver and gold. The lead-zinc product was shipped to Colorado and the lead concentrate smelted at Midvale. At Park City the large tailing mills, the Big Four and Broadwater, were closed indefinitely in September owing to the operation being unprofitable.

Crude ore treated at concentration mills and the metals contained in the concentrates produced and smelted in 1917 are given in the following table:

Mine production of metals from Utah concentrates in 1917.

By counties.

County.	Ore to concentrating mills.	Concentrates produced.						Total value of concentrates.
		Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Beaver	1,152	11,784	700.36	98,189	1,917,490	1,154,961	3,462,704	$1,071,384
Salt Lake	13,561,679	751,158	71,039.34	1,373,503	207,128,242	35,283,683	8,197,105	63,012,491
Summit	56,297	17,357	1,389.89	421,861	165,033	7,320,472	1,247,303	1,177,998
Tooele	38,472	13,898	102.47	160,744	563,578	3,749,709	6,005	611,515
Utah	2,874	958	12.65	15,113	1,994	385,199	....	46,385
Wasatch	58,186	18,132	438.56	400,394	351,366	6,112,201	3,954,453	1,363,917
	13,718,660	813,287	73,674.27	2,469,804	210,127,703	53,956,225	16,867,570	67,283,690

Mine production of metals from Utah concentrates in 1917—Continued.

By kinds of concentrates.

Description.	Quantity.	Gold.	Silver	Copper.	Lead.	Recoverable zinc.	Total value of concentrates.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds*	*Pounds.*	*Pounds.*	
Siliceous	120	5.61	2,391	1,994	....	....	$2,630
Copper	655,259	50,280.80	525,923	207,603,875	....	....	58,148,614
Lead	130,890	22,522.72	1,675,899	2,134,184	51,356,311		6,845,802
Zinc	14,094	294.14	131,615	168,483	655,534	9,210,334	1,156,357
Lead-zinc	12,924	571.00	133,976	219,167	1,944,380	7,657,236	1,130,287

All of the four smelting plants situated near Salt Lake City were operated at capacity during 1917. The United States smelter operated 7 furnaces on lead ore, the Murray plant of the American Smelting & Refining Co. had 8 furnaces treating lead ore, and its Garfield copper plant was operated at full capacity. At the International plant near Tooele 3 or 4 out of the 5 copper reverberatory furnaces were operated. There were smelted at International[1] in 1917, 320,510 tons of copper ore and 334,273 tons of lead ore, from which were produced 17,385,090 pounds of fine copper, 85,726,315 pounds of fine lead, 4,439,290 ounces of silver, and 31,495.23 ounces of gold. On account of the accumulation of ores and the shortage of railroad cars it became necessary at times for the smelters to declare embargoes in order to catch up with production of ore. The crude ores directly smelted in 1917 and their metallic content are given in the following table:

Mine production of metals from Utah crude ore shipped to smelters in 1917.

By counties.

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Beaver	52,739	1,487.69	199,373	1,783,858	4,145,170	670,760	$1,106,931
Box Elder	13,819	62.32	20,441	1,361,341	839,283	609,037	524,078
Cache	57	....	52	4,417	....	....	1,331
Emery	17	....	17	6,063	....	....	1,669
Garfield	9	17.24	36	2,749	....	....	1,139
Grand	86	1.11	4,692	14,439	....	....	7,831
Iron	449	3.94	1,441	78	156,243	....	14,726
Juab	302,218	39,465.91	4,522,805	8,242,017	30,366,194	992,076	9,505,379
Millard	178	18.60	374	16,267	8,322	....	5,850
Morgan	171	....	703	....	75,400	....	7,063
Piute	2,128	1,039.73	46,740	18,770	540,476	....	111,612
Salt Lake	637,086	38,670.29	2,393,459	19,624,867	51,596,816	629,553	12,630,725
San Juan	28	....	113	14,918	....	....	4,166
Sanpete	16	....	....	....	5,814	....	500
Summit	53,253	3,508.98	1,854,722	607,088	18,201,302	....	3,331,875
Tooele	82,455	1,454.67	630,504	3,600,215	11,201,922	1,300,969	2,628,528
Uinta	5	....	20	4,098	1,328	....	1,250
Utah	25,460	1,275.87	562,132	85,619	5,209,871	216,906	583,119
Wasatch	7,504	24.08	260,461	161,821	2,081,590	....	438,311
Washington	324	....	44	139,376	....	....	38,086
	1,178,002	87,030.43	10,498,129	35,688,301	124,429,731	4,419,301	31,344,169

---

[1] Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

Mine production of metals from Utah crude ore shipped to smelters in 1917—Continued.

By kinds of ore.

Kind of ore.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Dry or siliceous	97,786	18,846.31	1,834,547	1,760,377	974,835		$2,465,674
Copper	617,156	44,546.28	1,698,521	28,282,873	12,772		10,042,757
Lead	446,786	23,560.56	6,872,954	5,259,363	121,166,005		18,006,437
Zinc	6,535				60,078	3,664,962	378,993
Copper-lead	6,326	75.28	91,447	335,688	1,414,923		303,884
Lead-zinc	3,413	2.00	660		801,118	754,339	146,424

PRODUCTION BY COUNTIES.

GENERAL FEATURES.

The total output of the State by counties in 1917 and the mine production of each metal, with its total value, are shown in a table below; a second table shows production of ore and average value per ton by counties in 1916 and 1917; and a review describes the mining industry in each county and each producing mining district.

Mine production of gold, silver, copper, lead, and zinc in Utah in 1917.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.	Quantity (fine ounces).	Value.
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.			
Beaver			2,192.06	$45,314	$45,314	297,833	$245,415
Box Elder			188.32	3,893	3,893	20,464	16,862
Cache						52	43
Emery						17	14
Garfield			29.66	613	613	39	32
Grand	1.69	$35	1.11	23	58	4,692	3,866
Iron			3.92	81	81	1,441	1,187
Juab			40,809.59	843,609	843,609	4,988,005	4,110,116
Millard			18.62	385	385	374	308
Morgan						703	579
Piute			1,039.72	21,493	21,493	46,740	38,514
Salt Lake			109,747.59	2,268,684	2,268,684	3,769,884	3,106,385
San Juan						113	93
Sanpete							
Summit			4,889.89	101,083	101,083	2,276,583	1,875,904
Tooele			1,564.64	32,344	32,344	793,265	653,650
Uinta	3.73	77			77	20	17
Utah			1,352.47	27,958	27,958	618,009	509,240
Wasatch			462.66	9,564	9,564	660,855	544,545
Washington						44	36
	5.42	112	162,300.25	3,355,044	3,355,156	13,479,133	11,106,806

Mine production of gold, silver, copper, lead, and zinc in Utah in 1917—Con.

County.	Copper.		Lead.		Recoverable zinc.		Total value.
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	
Beaver	3,702,085	$1,010,669	5,321,400	$457,640	4,133,464	$421,613	$2,180,651
Box Elder	1,361,341	371,646	839,283	72,178	609,037	62,122	526,701
Cache	4,717	1,288	....	....	....	....	1,331
Emery	6,063	1,655	....	....	....	....	1,669
Garfield	2,749	751	....	....	....	....	1,396
Grand	14,439	3,942	....	....	....	....	7,866
Iron	78	21	156,243	13,437	....	....	14,726
Juab	9,060,565	2,473,534	30,367,586	2,611,612	992,076	101,192	10,140,063
Millard	16,267	4,441	8,322	716	....	....	5,850
Morgan	....	....	75,400	6,484	....	....	7,063
Piute	18,770	5,124	540,476	46,481	....	....	111,612
Salt Lake	226,774,390	61,909,408	86,863,950	7,470,300	8,826,658	900,319	75,655,096
San Juan	14,918	4,073	....	....	....	....	4,160
Sanpete	....	....	5,814	500	....	....	500
Summit	772,121	210,789	25,521,774	2,194,873	1,247,303	127,225	4,509,874
Tooele	4,181,231	1,141,476	15,031,521	1,292,711	1,306,974	133,311	3,253,492
Uinta	4,098	1,119	1,328	114	....	....	1,327
Utah	87,758	23,958	5,596,070	481,176	216,906	22,125	1,064,457
Wasatch	513,187	140,100	8,193,791	704,666	3,954,453	403,354	1,802,229
Washington	139,376	38,050	....	....	....	....	38,086
	246,674,153	67,342,044	178,521,958	15,352,888	21,286,871	2,171,261	99,328,155

Ore sold or treated, number of deep mines producing, and value of ores in Utah in 1916 and 1917.

County.	Ore sold or treated.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	1917	Increase or decrease.	1916	1917	1916	1917	1916	1917
	Short tons.	*Short tons.*						
Beaver	308,038	+ 31,897	49	60	$7.33	$7.08	$1.06	$0.94
Box Elder	13,989	− 1,218	6	12	45.26	37.65	.33	1.48
Cache	57	− 24	3	1	27.53	23.35	.79	.75
Emery	17	+ 17	....	1	....	98.18	....	.82
Garfield	24	− 6	1	1	8.66	58.17	8.66	26.87
Grand	86	+ 71	2	7	55.07	91.06	7.20	45.22
Iron	449	− 162	3	3	17.12	32.80	1.93	2.82
Juab	364,360	+ 11,579	58	51	24.65	27.83	11.55	13.60
Millard	178	+ 130	2	5	38.85	32.86	1.65	3.89
Morgan	171	+ 71	2	1	30.03	41.30	2.07	3.39
Piute	2,128	+ 1,802	7	7	56.91	52.45	42.09	28.20
Salt Lake	14,263,680	+1,432,019	81	80	5.36	5.30	.39	.33
San Juan	28	− 40	1	1	129.14	148.78	2.63	3.32
Sanpete	16	+ 16	....	1	....	31.25	....	....
Sevier	....	− 9	1	....	85.44	....	1.11	....
Summit	174,920	− 58,925	17	14	17.47	25.78	7.18	11.30
Tooele	132,048	+ 7,353	48	61	23.48	24.64	4.82	5.19
Uinta	5	....	1	3	270.20	250.00	3.66	3.40
Utah	32,273	+ 14,162	18	16	38.85	32.98	12.60	16.64
Wasatch	65,690	− 1,063	3	3	19.27	27.43	5.10	8.44
Washington	324	+ 160	7	3	51.09	117.55	2.77	.11
	15,358,481	+1,437,838	310	331	6.41	6.47	.88	.94

[a] Value per ton, placer product excluded.

BEAVER COUNTY.

Mine production in Beaver County, Utah, 1916–17.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ozs.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	49	276,141	$41,832	381,862	3,203,688	5,948,220	3,969,405	$2,023,531
1917	60	308,038	45,314	297,833	3,702,085	5,321,400	4,133,464	2,180,651
Increase or decrease, 1917		+31,897	+3,482	−84,029	+498,397	−626,820	+164,059	+157,120
Total, 1860–1917			767,739	21,160,906	49,638,383	411.403,954	33,507,519	49,392,527

Since 1860 this country has a record of gold, silver, copper, lead, and zinc amounting in total value to $49,392,527. This includes $767,739 in gold, $19,588,392 in silver, $8,478,593 in copper, $17,980,774 in lead, and $2,577,029 in zinc. The corresponding table of production by years is given to the end of the year 1913 in Mineral Resources for 1913, Part I, page 389.

Sixty mines in 1917 produced 308,038 tons of ore, against 49 mines and 276,141 tons of ore in 1916. The total value of the output of gold, silver, copper, lead, and zinc increased from $2,023,531 in 1916 to $2,180,651 in 1917. The quantity of the metals, with the exception of silver and lead, increased, and the total value of all the metals increased except that of silver and zinc. The value of the gold increased from $41,832 in 1916 to $45,314 in 1917; copper, from $788,107 to $1,010,669; and lead, from $410,427 to $457,640. Silver decreased from $251,265 to $245,415, and zinc from $531,900 to $421,613. The average value per ton of the ore, including some old slag, decreased from $7.33 in 1916 to $7.08 in 1917, and the gold and silver value per ton in this ore from $1.06 to 94 cents.

The decrease in the value per ton was caused by the treatment of considerable low-grade tailing. Of the ore mined, 1,152 tons were concentrated and produced lead and zinc concentrates. One plant treated a large quantity of tailing, yielding lead-zinc concentrates containing gold, silver, and copper. Copper concentrate continued to be produced from the re-treatment of the old Cactus mine tailings at Newhouse. Altogether there were 11,784 tons of concentrates having a total value of $1,071,384, or $90.82 per ton. Crude ore shipped, mostly oxidized, aggregated 52,739 tons, which yielded at the smelters gold, silver, copper, lead, and zinc having a total value of $1,106,931, or an average value per ton of $20.99.

Beaver Lake district.—Six producers shipped 341 tons of ore, which was principally oxidized copper ore. The total content of these ores was $186 in gold, 438 ounces of silver, 33,795 pounds of copper, and 2,277 pounds of lead, valued in all at $9,969, or an average value per ton of $29.23. The O. K. mine was the largest producer of copper ore, followed by smaller production from the Copper Mountain, Larkspur, Success, and Utah-United properties.

Bradshaw district.—Two small lots of lead ore containing silver were shipped from the Summit and Lower Cave properties.

Granite district.—The King of the Hills and the Amazon properties were operated and yielded a small tonnage of oxidized copper ore containing gold and silver.

Lincoln district.—Most of the ore produced in 1917 containing copper came from the Rattler property, and some test lots of lead ore came from the Croff mine. Part of this ore was milled and produced, besides the lead, a little copper and zinc accompanied by gold and silver. The Creole and the Stampede properties were also producers.

Newton district.—Very little work beyond that required in annual assessment was performed in 1917. A small quantity of gold and silver bullion, probably from previous operations, was reported from one property.

North Granite district.—One carload of low-grade oxidized copper ore, which barely paid its way to the smelter, was shipped from the Mammoth Copper property.

Preuss district.—The Indian Queen, Klondyke, and Galena properties were all producers of lead ore carrying small quantities of copper accompanied by a little gold and silver.

Rocky district.—Important developments on the Montreal property allowed the operators to ship a large quantity of oxidized copper-iron ore. This ore carried an average of 30 per cent of iron and 16 per cent of silica, making it valuable at the smelter as fluxing ore. The property is opened by an adit 1,000 feet long, in which there are drifts aggregating 1,500 feet. The Old Hickory mine, another producer of oxidized copper ore with higher silica and a lower average in iron, shipped a large quantity of ore. The Copper Ranch property also produced copper ore. In 1917 the district produced altogether 29,869 tons of ore, containing $2,005 in gold, 11,493 ounces of silver, 1,322,271 pounds of copper, valued in all at $372,455, or an average value per ton of $12.47.

Frisco district.—There were seven producers reporting the output and treatment of 266,134 tons of ore and old tailings, containing $27,439 in gold, 216,021 ounces of silver, 2,132,726 pounds of copper, 3,541,814 pounds of lead, and 3,538,898 pounds of recoverable zinc, valued in all at $1,453,237, or an average value per ton of $5.46. Of this production there were 11,107 tons of crude ore shipped directly to the smelter. From the old tailings and some crude ore of milling grade treated 11,724 tons of concentrates were shipped. In 1916 there were 12,425 tons of concentrates and 10,013 tons of crude ore shipped directly to the smelters. A new reduction plant, known as the Quad Metals mill, was built in 1917, at the Carbonate Rattler mine, 2 miles north of Frisco. It is equipped to treat the ores by flotation. The Horn Silver mine continued to be the largest producer of ore and yielded mixed lead sulphide and carbonate, also copper, and some zinc sulphide ores. Some of the ore was of milling grade and produced lead and zinc concentrates at the Midvale concentrator.

At Frisco the old tailing dump under lease to the Caldo Leasing Co., supplied material for the flotation mill, which produced a high-grade lead and zinc concentrate containing good values in silver. According to the annual report of the Horn Silver Co.,[1] the ore mined in 1917 came entirely from the upper levels, more especially from the 300 level, where small pockets of ore were found. Development work was continued on other levels above the 900. A portion of the shipments consisted of old "fillings." Developments on the 1,200-foot level have not progressed far enough to determine the question as to the occurrence of ore with depth.

---

[1] Horn Silver Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

At Newhouse the Utah Leasing Co. continued with its 700-ton flotation mill to treat the old Cactus mine tailing assaying about 0.65 per cent of copper, which yielded a copper concentrate containing gold and silver. There were also shipments from four other properties, including a small output from the Imperial property, operated by a lessee.

Star districts (*North and South*).—These districts in 1917 yielded from their mines 10,689 tons of ore, containing $14,688 in gold, 65,951 ounces of silver, 175,170 pounds of copper, 1,703,957 pounds of lead, and 588,106 pounds of recoverable zinc, valued in all at $323,380, or an average value per ton of $30.25. The largest producers were the Moscow and the Monitor properties. The former property ceased operations in September. It is said the mine was closed indefinitely on account of the low grade of the ore and the higher mining costs. There were three grades of ore shipped from the Moscow in 1917, consisting of copper, lead, and zinc oxidized ores. The property is opened by a vertical shaft 1,400 feet deep and two others 500 and 200 feet deep. Altogether there are about 10,000 feet of drifting. The other properties yielding more than 200 tons of ore were the Rebel & Wild Bill, Red Warrior, Paloma, and Cedar Talisman. Some lead ore was also shipped from the Blue John, Boston, Commonwealth, Magnolia, Hoosier Boy, and Osceola properties.

Washington district.—There were small quantities of oxidized copper ore shipped from the Mono and Copper Queen properties. The Mono produced also a small quantity of oxidized lead ore. All these ores carried some gold and silver.

BOX ELDER COUNTY.

Ashbrook district.—A small quantity of silver ore carrying a little gold was shipped from the Vipont mine in 1917.

Box Elder district.—A small production of lead ore carrying a little copper and silver was reported from one property in the district.

Lucin district.—Six producers reported the output of 12,023 tons of ore, containing $1,196 in gold, 19,016 ounces of silver, 1,359,169 pounds of copper, 521,209 pounds of lead, and 34,680 pounds of recoverable zinc, valued in all at $436,279, or an average value per ton of $36.29. All of the ore produced was of smelting grade, with the exception of that shipped for its zinc content, which is reported to have been stored at the smelting works at Murray for future treatment. The largest production of copper ore was that made by lessees on the property of the Salt Lake Copper Co., which shipped the output.

Considerable lead ore was shipped from the old Teeoma mine, which had been idle for 40 years. Occasionally shipments were made by lessees. The company operating the property also shipped some oxidized zinc ore, containing about 18 per cent of zinc, 44 per cent of iron, and a low percentage of silica. The Cunapah (which was erroneously listed on the Nevada side of the line in the Tecoma district in 1916) produced in 1917 considerable oxidized lead ore carrying a little silver and gold. There were also shipments of oxidized lead ore from the Lucin Copper and Mineral Mountain properties.

Newfoundland district.—The Mineral Monarch was a producer of a small quantity of oxidized copper ore in 1917.

Park Valley district.—The Susannah property was operated by a lessee, and some gold and silver bullion was produced by amalgamation.

Promontory district.—The Lake View and Big Pine properties were the only producers, both of them yielding some lead ore. The largest part of the output of the Lakeview, the principal producer, consisted of oxidized zinc ore shipped to eastern smelting plants.

CACHE COUNTY.

Paradise district.—The Wolf Mountain copper property, which is opened by a 45-foot vertical shaft and also an incline shaft 40 feet deep, yielded a small quantity of copper ore containing a little silver.

EMERY COUNTY.

Lost Springs district.—A small shipment of copper ore containing a little silver was reported from this locality.

GARFIELD COUNTY.

Imperial district.—The Fortuna Independence Co., operating the Bromide property, shipped a small quantity of gold bullion and crude smelting ore, which contained gold, silver, and copper.

GRAND COUNTY.

Klondyke district.—The Rambler property is reported to have produced a small quantity of ore carrying copper and silver, shipped directly to the smelter.

La Sal district.—There were six small shipments of copper ore in 1917 aggregating 73 tons, valued at $7,374, principally for the silver content.

IRON COUNTY.

Calumet district.—From the Calumet property there were shipped 443 tons of oxidized lead ore carrying an average of about 20 per cent of lead and 1 ounce of silver per ton. Sahara station on the Salt Lake Route, 28 miles from the mine, was the loading point for the ore.

Stateline district.—Very little work was done in the district in 1917. Several small shipments of silver product were reported, which probably came from previous operations.

JUAB COUNTY.

Fifty-one producers in 1917 mined an output of 364,360 tons of ore, containing gold, silver, copper lead, and zinc, valued at $10,140,063—an increase of 11,579 tons in quantity and of $1,443,402 in value, as compared with the output of 58 producers in 1916 of 352,781 tons, valued at $8,686,661. The output was mainly from the Tintic district.

Detroit district.—The Ibex Gold property produced a small quantity of oxidized copper ore carrying considerable gold and a little silver.

Fish Springs district.—At the Utah mine a concentration mill is being erected to treat the old ore dumps. In 1917 there were several shipments of lead ore carrying silver.

Mount Nebo district.—From the Emma property a few tons of lead sulphide ore carrying silver were shipped to the smelter. There were also shipments from the Highland property, and zinc-lead ore and lead ore from the Mount Nebo mine and a property operated by the Gunnison Development Co.

Tintic district.—The total value of the metals produced in this district from 1869 to the end of 1917 was $180,401,804, distributed as follows: Gold, $32,556,936; silver, $83,343,232; copper, $27,552,435; lead, $35,358,411; zinc, $1,590,790.

The larger part of the Tintic district is in Juab County and the remainder in Utah County.

Mine production in Tintic district, Utah, 1916–1917.

County.	Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
			Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Juab	1916	44	348,737	$834,841	4,848,047	7,085,704	35,425,153	2,414,089	$8,535,763
	1917	42	363,746	842,593	4,975,854	9,045,595	30,132,739	966,035	10,102,095
Utah	1916	10	17,212	20,613	265,519	20,941	3,869,198	1,297,067	641,258
	1917	7	28,640	25,954	582,909	72,128	4,946,210	216,906	973,461
	1916	54	365,949	855,454	5,113,566	7,106,645	39,294,351	3,711,156	9,177,021
	1917	49	392,386	868,547	5,558,763	9,117,723	35,078,949	1,182,941	11,075,556
Total, 1869–1917				32,556,936	125,271,682	171,493,635	752,049,426	16,803,653	180,401,804

The value of the metals produced in 1917 was distributed as follows: Gold, $868,547, against $855,454 in 1916; silver, $4,580,421, against $3,364,727 in 1916; copper, $2,489,138, against $1,748,234 in 1916; lead, $3,016,789, against $2,711,311 in 1916; zinc, $120,661, against $497,295 in 1916.

Altogether there were 49 producers in the district whose output was valued at $11,075,556, or an average per ton of ore sold or treated of $28.23. In 1916 the output was valued at $9,177,021, or an average value per ton of $25.08. As in the two preceding years there was a large quantity of old mine-dump material of sufficient value to ship at the prevailing high prices for the metals. The following table gives the quantity and kinds of ore produced in the district in 1917, the number of producers, and the metallic content of each kind of ore:

Mine production in Tintic district, Utah, in 1917, by kinds of ore.

Kind of ore.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Dry or siliceous	26	141,520	19,601.50	1,580,119	2,530,681	1,392	....
Copper	21	96,844	12,292.05	846,010	6,207,754	....	....
Lead	30	151,878	10,122.05	3,132,519	379,117	35,003,567	....
Zinc	10	1,883	....	....	....	....	1,096,807
Copper-lead	1	3	.38	115	171	818	....
Lead-zinc	2	258	....	....	....	73,172	86,134
		392,386	42,015.98	5,558,763	9,117,723	35,078,949	1,182,941

Of interest to Tintic mine operators is the driving of a drainage adit, 6 miles long, by the Tintic Drain Tunnel Co., a Knight enterprise. The adit starts from the Goshen slope and runs to the porphyry section at the southern end of the district, in the direction of the Dragon Consolidated property. When completed the adit will have an approximate depth of 2,200 feet below the collar of the Iron Blossom and Dragon shafts.

Another development work recently started was the sinking of the North-Beck shaft, which, at the end of 1917, had attained a depth of nearly 1,000 feet. This is a shaft sunk for the purpose of prospecting for ore in the northern extension of the western ore zone of the camp on which the Eureka Hill, Centennial Eureka, Bullion Beck, and Gemini properties are located.

At the Standard mine new ore deposits were added to the reserve and about 300 cars were shipped directly to the smelters. The new No. 2 shaft disclosed ore on the 1,260-foot level, which assays 75 ounces of silver and $10 in gold per ton, and 10 per cent of lead and about 2 per cent of copper. Picked samples are said to have assayed as high as 410 ounces of silver and $36 in gold per ton. The Standard has paid a total of $81,941 in dividends, all of which was distributed in 1917.

The Chief Consolidated enlarged its main shaft to a 2-compartment shaft extending to the water level depth at 1,800 feet, without interfering with the production. Some unusually rich ore was reported at about water level and high-grade ore was stoped below water level, but little mining was done pending the installation of permanent pumps. Several cars of ore valued at $10,000 were shipped from this part of the mine. According to the company's report,[1] the total shipments of dry ore in 1917 aggregated 59,950 tons, which yielded, after payment of smelting, transportation, and sampling charges, a net value of $1,554,714. This value is greater and the tonnage is less than that of the output in 1916.

The metals contained in the output of silver, lead, and zinc ores for 1917 were 9,175 ounces of gold, 1,534,907 ounces of silver, 10,780,540 pounds of lead, and 600,236 pounds of zinc. The zinc-lead ores contained 90,511 pounds of zinc and 66,170 pounds of lead. The average content was 0.153 ounce of gold and 25.6 ounces of silver per ton, and 11.92 per cent of lead (in lead ore) and 36.16 per cent of zinc (in zinc ore). The zinc-lead ore contained 20.29 per cent of zinc and 14.84 per cent of lead. The ore was classified as 45,231 tons of silver-lead ore, 13,666 tons of dry ore (with no lead or copper), 830 tons of zinc ore, and 223 tons of zinc-lead ore. The total average value per ton of the ore shipped in 1917 was $40.12, as against $31.52 in 1916 and $20.55 in 1915, and the net value, respectively, was $25.93, $18.64, and $9.96. The total dividends paid since February 3, 1913, amount to $836,969, including $309,451 paid in 1917. The following paragraph is from the company's annual report:

---

[1] Chief Consolidated Mining Co. Ninth Ann. Rept., for year ending Dec. 31, 1917.

> The new ore channel on the 1,800 level, referred to in the last quarterly report, has given a continual product of ordinary lead carbonate ore. This ore was followed down to and below the water level and then proved to be of higher grade.
>
> The ore production during this year was principally derived from the 700, 800, 1,600 and 1,800 levels. During the latter part of the year, as mentioned in the preceding quarterly report, the ore shipments were curtailed on account of the insufficient capacities of the smelters. This condition exists today, together with higher treatment charges, taxes, and operating costs. This makes it imperative to ship the highest-grade ores, as only a small tonnage will be accepted by the smelters. On account of these adverse conditions practically all development work has been suspended until a more auspicious time. As this work has been carried well ahead, its neglect will not hamper the mining operations for some time.

The Iron Blossom mine is opened by one of its shafts to a depth of 2,200 feet. In 1917 this property[1] produced 10,458 tons of siliceous ore, which contained 1,406.37 ounces of gold and 239,246.91 ounces of silver. In 7,010 tons of copper ore there were 166.72 ounces of gold, 42,310.94 ounces of silver, 684,275 pounds of copper, and 5,491 pounds of lead; and in 4,466 tons of lead ore there were 422.58 ounces of gold, 104,535.92 ounces of silver, and 619,056 pounds of lead. This output included one lot of zinc ore containing 12,210 pounds of zinc. Lessees added to the above output by shipping 3,487 tons of lead ore and 1,318 tons of copper ore and siliceous ore. There were 8,355 tons of milling ore shipped to the Silver City mill, which was treated by the chloridizing roasting process. This ore contained 669.55 ounces of gold, 82,645.80 ounces of silver, and 148,870 pounds of copper. Siliceous ore also treated—14,057 tons—contained 1,644.18 ounces of gold and 271,311.82 ounces of silver. From all ore sales the total amount received was $526,909. Dividends in 1917 amounted to $250,000. The company report says:

> With the object in view of getting through the siliceous beds of lime on the 1,900 level and developing a more soluble lime more susceptible to minerals, we have commenced sinking No. 1 shaft to a depth of 2,200 feet, 300 feet deeper than the 1,900 foot level. * * *
>
> The 1,100 drift on the east vein at No. 1 shaft has been continued south to a point near the Dragon north end line, and has developed a commercial body of low-grade copper and silver ore, suitable for the mill treatment. This ore has every appearance of extending down to deeper levels. * * *
>
> Due to the scarcity of labor and the advisability of mining smaller streaks of ore from the old stopes, the system of leasing has been adopted for the greater part of the mine, which has given very satisfactory results. The system of leasing is on the following royalty basis: Up to $10 per ton, 20 per cent royalty was paid; $10 to $15 per ton, 25 per cent; $15 to $20 per ton, 30 per cent; $20 to $25 per ton, 35 per cent; $25 to $30 per ton, 40 per cent; and $30 and up, 50 per cent.

---

[1] Iron Blossom Consolidated Mining Co. Ann. Rept. for year ending Nov. 30, 1917.

The ores from the "Van" stope, which comprise most of the ore shipped to the Tintic Milling Co., and the copper ores from what is known as the 600 winze copper stopes, are mined under company operations.

At the Centennial-Eureka mine[1] 50,132 tons of ore were produced. Developments were carried on mostly in the vicinity of old stopes, and extraction obtained mainly from these stopes. The Bullion Beck & Champion property[2] yielded 5,700 dry tons of ore, most of which was produced by lessees.

In 1917 the Eagle & Blue Bell mine[3] produced 33,252 dry tons of lead carbonate and sulphide ore, and 1,205 tons of silicious gold and silver ore carrying a little copper. The lead ore contained 2,608.99 ounces of gold, 507,350 ounces of silver, 9,069,091 pounds of lead, and 1,007 pounds of copper, and the dry siliceous ore contained 210.05 ounces of gold, 12,530 ounces of silver, and 3,082 pounds of copper. The total value of the ore was $1,068,836.92, an increase of $537,986 over the value in 1916. Notwithstanding the embargoes by railroads and smelters on the movement of ore, the output in 1917 exceeded that of 1916 by 8,862 tons. Dividends paid, beginning in the year 1913 and including the dividend in 1917 of $357,258.40, amounted to $893,146. The workings in the North Extension claims continue to produce lead-silver ore from the 1,000-foot level, and the ore is being followed in a more or less irregular way along a general northwesterly course through these claims. The company's report continues as follows:

> From the 1,700 level up to a point within 60 feet vertically below the 1,350 level, making a total vertical distance of 290 feet, stoping and development work has been under way all the year with most satisfactory results. The present working faces in this immediate vicinity indicate a continuation of ore from which we can expect a fair tonnage for some time. An extension of the ore body has also been followed below the 1,700 level, and at a point 60 feet above the 1,875 level a fair sized stope has been made. We expect this deposit to persist to greater depth and at different horizons show as marked continuity as above.

The Tintic Milling Co.[4] reports receiving $542,180 in 1917 for precipitates and base bullion containing principally silver and copper recovered from custom ores. Treatment of the ores consists of a chloridizing roast and the leaching of the residue. The ores treated were produced chiefly from the Dragon and Iron Blossom mines and a number of others known as the Knight properties. Several shippers in the district took advantage of lower milling rates offsetting the railroad haul and charges at smelters for low-grade ores.

The Victoria mine[5] produced almost twice as much ore in 1917 as in 1916. There were produced 2,761 tons of lead-silver ore, containing 599.88 ounces of gold, 102,664 ounces of silver, 515,993 pounds of lead, and 16,825 pounds of copper; and 10,782 tons of siliceous ore contained 2,275.48 ounces of gold, 236,087 ounces of silver, and 102,728 pounds of copper. The Victoria is operated through the Eagle & Blue Bell shaft No. 1, and most of the high-grade lead-silver and siliceous ore was mined from the 1,050-foot level. Some of this ore also carries high gold values. The deposit is being followed to the north and south.

---

[1] United States Smelting, Refining & Mining Co. Twelfth Ann. Rept., for year ending Dec. 31, 1917.

[2] Idem.

[3] Eagle & Blue Bell Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

[4] Tintic Milling Co. Ann. Rept. for year ending Dec. 31, 1917.

[5] Bingham Mines Co. Ninth Ann. Rept., for year ending Dec. 31, 1917.

West Tintic district.—Copper ore from the Desert Mountain property and oxidized lead ore carrying silver from the Scotia and Imperial lead properties, were the only shipments from the district in 1917.

MILLARD COUNTY.

Antelope district.—A small shipment of oxidized lead ore was made from the Antelope Star property in 1917.

Detroit district.—Oxidized copper ore, containing gold and silver, was shipped from the Copper Head, Columbus, and one other property in this district in 1917.

Leamington district.—From the Silver Maple property lessees shipped some lead sulphide ore carrying a little silver.

MORGAN COUNTY.

Argenta district.—The Carbonate group was operated in 1917 and yielded a small quantity of lead ore of shipping grade containing silver.

PIUTE COUNTY.

Gold Mountain district.—A few tons of gold ore from the Annie Laurie property was shipped to the smelter in 1917.

Mount Baldy district.—The Deer Trail property was equipped with a modern milling plant, which was nearly ready for operation at the close of 1917. There were shipments of lead ore, containing gold, silver, and a little copper, made directly to the smelters during the year. The Pluto property produced copper ore, containing gold and silver.

Ohio district.—The Great Western, Wedge, Bullion, and Shamrock properties were producers in 1917 of small quantities of shipping ore, the first-named property being the largest producer of lead sulphide ore carrying gold, silver, and a little copper.

SALT LAKE COUNTY.

In Salt Lake County 80 operators produced 14,263,680 tons of ore, which was 1,432,019 tons more than was produced in 1916 by 81 operators. The total average value per ton of the ore for the gold, silver, copper, lead, and zinc content decreased from $5.36 to $5.30, and the gold and silver average value per ton of this ore decreased from 39 cents to 38 cents. A review of the principal districts follows:

Big Cottonwood and Little Cottonwood districts.—From 1867 to the end of 1917 these districts have a record of producing 429,495 tons of ore, valued at $25,722,553, which includes $500,529 in gold, $13,215,039 in silver, $1,741,962 in copper, $10,225,640 in lead, and $39,283 in zinc. The table of production by years is given to the end of 1914 in a recent report[1] of the Survey.

---

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 740, 1915.

Mine production in Big Cottonwood and Little Cottonwood mining districts, Utah, 1916–17.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	31	41,960	$21,414	755,980	819,192	15,061,273	60,746	$1,767,738
1917	32	48,203	18,611	917,512	1,163,084	11,927,552	21,721	2,120,149
Increase or decrease, 1917		+6,243	−2,803	+161,532	+343,892	−3,133,721	−39,025	+352,411
Total, 1867–1917		429,495	500,529	13,140,345	9,855,917	180,616,785	320,934	25,722,553

Thirty-two producers in 1917 shipped directly to the smelters 48,203 tons of ore, of which 29,760 tons came from the mines in the vicinity of Alta and the remainder was principally from the Cardiff and Maxfield properties in the Big Cottonwood Canyon. The ore produced in these districts contained $18,611 in gold, 917,512 ounces of silver, 1,163,084 pounds of copper, 11,927,552 pounds of lead, and 21,721 pounds of recoverable zinc, valued in all at $2,120,149, or an average value per ton of $43.98. Shipments from Big Cottonwood were reported from the American Consolidated, Big Cottonwood Coalition, Cardiff, Iowa Copper, Maxfield, Prince of Wales, and Woodlawn. From Little Cottonwood the producers were the Albion, Alta Consolidated, Alta Michigan, Alta Utah, Cabin, Wasatch Mines, Columbus Rexall, Emma, Michigan-Utah, Peruvian, Sells, South Hecla, South Hecla Extension, and Alta Wasatch.

The Wasatch Mines Co. in June continued to work on its new drainage adit, started in the Little Cottonwood Canyon 5,000 feet from the main workings, and drove 1,700 feet in an easterly direction in 1917. This adit is expected to unwater the old Columbus Consolidated stopes.

Work on the Alta tunnel project, which started from near the head of Silver Fork Canyon on the Big Cottonwood side of the divide, was completed for a length of 3,000 feet.

Nearly 9,000 tons of ore of an average value of $30.58, mainly for silver and lead, were reported to have been shipped from the old Emma mine.

On July 9 the Columbus Rexall miners, working under the summit of the Little and Big Cottonwood divide at a depth of almost 1,700 feet and 5,000 feet from the portal of its transportation adit, opened a deposit of copper ore, replacing lime shale. This deposit where encountered was only a few inches thick, but subsequently widened to an average of 21 feet, dipping about 30° E. At the end of 1917 the ore body had been followed in an upraise 60 feet westerly on its dip, and at this writing (June, 1918) the face of the upraise is about 200 feet from the adit level. In May, 1918, the adit was continued in its northerly course, and at a point 60 feet from where the first ore body was encountered a similar deposit was opened on June 2. The ore shipped to the smelters in 1917 aggregated 2,778 tons, containing 8 to 9 per cent of copper, and 8 to 15 ounces of silver and 50 to 65 cents per ton in gold. The insoluble matter in this ore averaged about 5 per cent, with 31 per cent of sulphur, 4 per cent of speiss, and less than 1 per cent of zinc.

The Michigan-Utah mines,[1] operated largely by lessees in 1917, yielded 12,014 tons of ore, containing 227.49 ounces of gold, 148,317.65 ounces of silver, 384,906 pounds of copper, and 1,865,379 pounds of lead. The sum received from sales of ore amounted to $226,408. Most of the ore was mined from the City Rocks vein through Copper Prince tunnel, which opens a large body of medium-grade copper ore situated near the portal. Average assays of the ore give 0.025 ounce of gold, 1.84 per cent of copper, 52.2 per cent of iron, 7.8 per cent of insoluble, 2.65 per cent of sulphur, and 0.6 per cent of manganese. On Patsy Marley Hill the openings made by lessees have disclosed a good body of copper ore in the Florida claim. At the present time this company operates an aerial tramway 4½ miles to Tanners Flat, where the ore is loaded on wagons and hauled 3½ miles to Wasatch, thence by the Denver & Rio Grande Railroad to Midvale.

From the South Hecla property[2] 3,798 tons of ore mined on company account and 727 tons by lessees contained a total of 164.23 ounces of gold, 76,784 ounces of silver, 711,896 pounds of lead, and 29,058 pounds of copper, valued in all at $117,664.34. The ore developments have been confined principally to the Wedge vein, which has been opened near the western end of the property by the so-called Wedge shaft, by levels driven along the vein at an average depth of 120 feet on its dip, and by some limited but important workings on the east end of the vein system over a mile away from the main development.

Smelter district.—Old tailing, sorted slag dump material, and a little ore, aggregating 65,083 tons, yielded principally concentrate. The total output contained $8,921 in gold, 66,252 ounces of silver, 199,631 pounds of copper, 1,412,690 pounds of lead, and 4,201,463 pounds of recoverable zinc, valued in all at $668,052. There were 8,122 tons of concentrate containing zinc, lead, gold, and silver, and 64,915 tons of old tailing and slag shipped directly to the smelter; also 168 tons of ore picked up from the railroad yards was sold to the smelters by a number of track pickers. The tailing dumps were worked by the Midvale Minerals Co. and the Childers Leasing Co., both treating the material from the milling operations of early days as well as from recent work.

Bingham or West Mountain district.—The output of the Bingham district from 1865 to 1917, inclusive, is valued at $31,318,190 in gold, $35,665,120 in silver, $296,608,198 in copper, $52,429,453 in lead, and $3,678,727 in zinc, a total gross value of $419,699,688, out of which dividends (partly estimated) amounting to $88,912,019 have been paid. The table giving the production by years may be consulted in Mineral Resources for 1913, Part I, page 399.

---

[1] Michigan-Utah Consolidated Mines Co. First Ann. Rept., for year ending Dec. 31, 1917.
[2] South Hecla Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

Mine production in Bingham or West Mountain district, Utah, 1916–17.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	45	12,777,683	$2,490,158	3,095,335	223,619,609	85,996,490	10,765,192	$66,913,606
1917	33	14,150,394	2,241,152	2,786,120	225,411,675	73,523,708	4,603,474	72,866,895
Increase or decrease, 1917	......	+1,372,711	− 249,006	− 309,215	+ 1,792,066	−12,472,782	−6,161,718	+5,953,289
Total, 1865–1917	......	....	31,318,190	48,415,824	1,658,636,866	1,058,092,538	40,052,718	419,699,688

The district in 1917 yielded 14,150,394 tons of ore, against 12,777,683 tons in 1916, 9,693,184 tons in 1915, 7,800,661 tons in 1914, and 9,190,374 tons in 1913. The total metallic value of the ores in 1917 was $72,866,895, or an average value per ton of $5.15, against a total of $66,913,606, with an average value per ton of $5.24 in 1916. The value of the output of gold decreased from $2,490,158 in 1916 to $2,241,152 in 1917; silver increased from $2,036,730 to $2,295,763. The value of the copper increased from $55,010,424 to $61,537,387; lead, from $5,933,758 to $6,323,039; and zinc decreased from $1,442,536 to $469,554. Shipments of ore to the smelters amounted to 588,715 tons, against 741,840 tons in 1916, 539,939 tons in 1915, 532,130 tons in 1914, 655,634 tons in 1913, and 502,682 tons in 1912. The output of concentrating ores was 13,561,679 tons, against 12,034,343 tons in 1916, 9,152,918 tons in 1915, 7,268,472 tons in 1914, and 8,527,755 tons in 1913. The quantity of concentrates produced was 743,036 tons in 1917, against 676,557 tons in 1916, 523,753 tons in 1915, 435,903 tons in 1914, and 443,640 tons in 1913.

The crude smelting ore in 1917 consisted principally of low-grade copper and lead sulphides and contained 37,760.36 ounces of gold, 1,472,528 ounces of silver, 18,455,113 pounds of copper, 39,618,966 pounds of lead, and 607,832 pounds of recoverable zinc, valued in all at $10,501,418, or an average value per ton of $17.84. Milling ores produced 743,036 tons of copper, lead, and zinc concentrates that contained 70,655.35 ounces of gold, 1,313,592 ounces of silver, 206,955,348 pounds of copper, 33,904,712 pounds of lead, and 3,995,642 pounds of recoverable zinc, valued in all at $62,365,146, or an average value per ton of $83.93.

Mine production in Bingham district, Utah, in 1917.

Kind of ore.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Dry or siliceous	2	425	21.93	1,850	6,539	454	....
Copper	23	13,739,880	81,136.28	1,177,906	222,301,095	2,640	....
Lead	25	234,711	8,709.04	947,226	2,185,602	44,896,903	....
Lead-zinc	7	175,378	18,548.46	659,138	918,439	28,623,711	4,603,474
		14,150,394	108,415.71	2,786,120	225,411,675	73,523,708	4,603,474

In 1917 the mines of the Utah Copper Co.[1] produced 12,542,000 tons of concentrating ore mined by the steam-shovel method and in addition 38,708 tons of ore containing copper, lead, and zinc mined by underground methods from the Sulphide mine and shipped directly to the smelter. These figures compare with a total of 10,994,000 tons of ore concentrated and 18,026 tons directly smelted in 1916. At the Magna concentrator 7,077,200 tons of ore were milled and at the Arthur plant 5,464,800 tons, or an average of 19,390 tons and 14,972 tons, respectively, each day during 1917. The gross production of copper from concentrates for 1917 was 204,855,118 pounds, and the shipments of crude ore contained an additional 1,319,324 pounds. After making smelter deductions, the net production was 195,837,111 pounds. In addition, there were produced 51,112 ounces of gold and 498,820 ounces of silver. The total dividends paid by this company amount to $75,770,882.50, including $23,555,105 paid in 1917. The following paragraphs are taken from the company's annual report:

> No effort was made to add to the ore-bearing area of 226.3 acres, but the churn drilling done during the year increased the calculated average thickness of developed and partially developed ore from 524 to 538 feet. Revised estimates show that previous to January 1, 1918, there had been developed in the property 438,972,700 tons of ore, averaging 1.40 per cent copper, of which quantity 270,000,000 tons are classed as fully developed and 168,972,700 tons as partly developed. There was mined from the entire property prior to January 1, 1918, a total of 67,220,700 tons of ore, averaging 1.428 per cent copper, and the total reserves remaining therefore amount to 371,752,000 tons, averaging 1.39 per cent copper. The year's addition to reserves was 1,906,442 tons in excess of the tonnage mined during that period. * * *
>
> The average grade of the ore milled at both plants (Magna and Arthur) was 1.337 per cent copper, as compared with 1.435 per cent copper for 1916. This reduction in grade was due to the fact that it was necessary to mine a considerable quantity of low-grade ore on the upper and lower-grade steam shovel levels. The average recovery at both plants was 61.10 per cent, corresponding to 16.3335 pounds of copper per ton, as compared to 62.34 per cent, or 17.8963 pounds per ton, for the previous year. The percentage of recovery was low because of the unsettled operating conditions in the mills, due to the various improvements under way, the unusually large tonnage treated, and comparatively low copper content in the headings. The average normal and metallurgically economical capacity of the two plants during the year was about 24,000 tons per day, whereas in order to maintain maximum production of copper a daily average of 34,362 tons was milled.
>
> The milling cost at Magna was 62.28 cents per ton and at Arthur 78.40 cents per ton, as compared with 35.35 cents and 40.94 cents, respectively, for the year 1916. The average cost at both plants was 69.30 cents per ton, as compared with 37.82 cents for the previous year, or an increase of 31.48 cents per ton. This very great increase was due partly to the higher costs of labor and supplies and partly to the lower grade of the ore, but in great part to the necessarily large charge made against operations for increased State and Federal taxes. * * *
>
> The production of copper for the year, from all sources, by quarters, and for the years 1915 and 1916, was as follows:

Quarter.	1915	1916	1917
	Pounds.	*Pounds.*	*Pounds.*
First	26,415,995	36,673,007	43,060,450
Second	40,799,825	48,726,304	56,845,059
Third	44,766,841	61,181,870	54,999,468
Fourth	44,224,715	50,836,299	51,269,465
	156,207,376	197,417,480	206,174,442

---

[1] Utah Copper Co. Thirteenth Ann. Rept., for year ending Dec. 31, 1917.

The average cost per net pound of copper produced from concentrates, after allowing for smelter deductions and after crediting precious metal values and miscellaneous income in Utah, was 10.952 cents, as compared with 6.918 cents for 1916. The net value of the gold and silver recovered amounted to 0.70 cent per pound. The miscellaneous income in Utah, including that from the Bingham & Garfield Railway, amounted to 0.988 cent per pound. This cost includes depreciation, all taxes as estimated and set up in tax reserves during the year, all general, fixed, and maintenance charges of every kind, and all expenses of smelting, transportation, refining, and selling. The average net cost, on the same basis, for all copper produced was 10.995 cents per pound. The operating costs on concentrating ore, including all fixed, general, and maintenance charges, for the years 1910 to 1917, inclusive, are shown in the table below:

Average cost per ton of mining, transportation, and milling in property of Utah Copper Co., 1910–1917.

Year.	Tonnage.	Mining.	Transportation.	Milling.	Total.
1910	4,340,245	$0.4097	$0.2978	$0.4663	$1.1738
1911	4,680,801	.4479	.3078	.4168	1.1725
1912	5,315,321	.4233	.2848	.4158	1.1239
1913	7,519,392	.3288	2797	.3676	.9761
1914	6,470,166	.3232	.2782	.3536	.9550
1915	8,494,300	.2441	.2781	.3402	.8624
1916	10,994,000	.2781	.2792	.3782	.9355
1917	12,542,000	.4446	.2794	.6930	1.4170

With the exception of a few minor changes and additions, the leaching plant was completed and put in operation during the month of December. Since then operations have been hampered by the difficulties usually experienced in starting a new plant, as well as by cold and stormy weather. * * * The indications are that it will have a capacity of from 2,000 to 4,000 tons per day. * * *

Construction of the acid plant, the ownership of which is divided equally between the Utah Copper Co. and the Garfield Smelting Co., was delayed on account of slow delivery of materials. * * * It has now attained an average rate of about 115 tons of 50° acid per day, for all of which there is a ready market. * * * It is expected that minor improvements and additions will be completed about May 1, 1918.

The United States Mining Co.'s properties yielded 85,402 dry tons of copper ore and 120,669 dry tons of lead ore. Some ore in addition to this was mined by lessees. The company's annual report contains the following paragraph[1]:

> The improved facilities made it possible not only to replace by development work the large tonnage extracted, but to add materially to the reserves in sight. Indications are very good for equally good developments in the future. It may be stated as an important fact that developments on the Niagara tunnel level have demonstrated that the ore bodies continue with undiminished strength to this level, and may be expected to continue for some depth below it.

The Bingham Mines Co., owning the Dalton & Lark mine, produced lead-silver and copper ores. It did some development work on the Yosemite but did not operate the Commercial mine.

The Dalton & Lark property[2] produced 7,057 dry tons of lead sulphide ore, 18,345 tons of copper sulphide ore, and 374 tons of iron sulphide ore. Altogether the ores shipped from these mines contained 1,872.05 ounces of gold, 139,240 ounces of silver, 1,681,848 pounds of lead, and 679,007 pounds of copper. Lessees operating in these properties mined 8.336 tons of lead and copper ore. The iron sulphide ore was purchased by the smelter for experimental purposes and was said to assay 39.6 per cent of sulphur, 25 per cent of iron, 0.03 ounce of gold, and 1.75 ounces of silver. The operations of this group of properties in 1917 were confined to the exploitation of every available showing and the development for the continuation of known ore deposits.

---

[1] United States Smelting, Refining & Mining Co. Twelfth Ann. Rept., for year ending Dec. 31, 1917.

[2] Bingham Mines Co. Ninth Ann. Rept., for year ending Dec. 31, 1917.

The Ohio Copper Mill, at Lark, was remodeled to use the flotation process, which is expected to be in operation and to treat 3,000 tons of ore daily in the summer of 1918. Mineral Separation machines, Hardinge mills, and Dorr thickeners and classifiers were installed.

The Montana-Bingham Co. continued driving its tunnel under the Fortuna ground recently purchased. Low-grade pyritic copper ores were shipped, and a mill was built at the Fortuna mine, and concentrates were produced.

The Highland Boy mine[1] produced 7,968,165 pounds of copper, 13,014,841 pounds of lead, 408,560 ounces of silver, and 13,530 ounces of gold, contained in ore as follows:

Average assay per ton of crude ore shipped from the Highland Boy mine, Utah, in 1917.

Material.	Dry ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Per cent.*	*Per cent.*
Copper-iron sulphide ore	226,536	0.050	0.764	1.797	....
Lead sulphide ore	58,247	.039	4.567	.610	13.913

At the Utah Apex property[2] operations were unfortunately delayed about three months by a fire which occurred in the mine during the early part of 1917. The total ore produced aggregated 118,694 tons, of which 101,057 tons were of shipping grade and 17,637 tons were lead ore of milling grade. The metals contained in this output were 3,551 ounces of gold, 396,989 ounces of silver, and 24,414,451 pounds of lead.

In 1917 the Utah Metal & Tunnel Co.[3] produced from its ores 4,612 ounces of gold, 242,003 ounces of silver, 659,127 pounds of copper, and 5,348,610 pounds of lead, valued in all at $884,687.88. This output includes the ore mined from the Bingham-New Haven property taken under control by the Utah Metal Co. in 1915. The dividends paid in 1917 amounted to $553,261.67.

SAN JUAN COUNTY.

In October the 300-ton mill erected on the Big Indian property was reported to be complete, and there was plenty of ore in the bins to commence operations. The plant is designed for the sulphurous acid leaching process, patented by Niels C. Christensen, for the treatement of copper ore. Sufficient sulphur for the first operation was hauled from the railroad. The mill was operated a short time, but closed, it is said, for certain alterations, which were not completed at the end of 1917.

---

[1] Utah Consolidated Mining Co. Ann. Rept., for year ending Dec. 31, 1917.
[2] Utah Apex Mining Co. Ann. Rept. for year ending Aug. 31, 1917.
[3] Utah Metal & Tunnel Co. Third Ann. Rept., for year ending Dec. 31, 1917.

White Canyon district.—The Copper Point property produced 28 tons of ore, averaging about 25 per cent of copper, and 3½ ounces of silver per ton.

SANPETE COUNTY.

Ephraim district.—The Sanpete Central property, 6 miles west of Ephraim, was a producer of a small quantity of lead ore in 1917.

SUMMIT AND WASATCH COUNTIES.

The principal producing area in Summit and Wasatch counties is the Park City region, which embraces the Blue Ledge, Snake Creek, and Uinta district. All but the first-named were credited with an output in 1917 of gold, silver, copper, lead, and zinc, valued at $6,312,103. This value added to the value of the production of metals since 1870 amounts to the sum of $169,814,024, which includes $4,367,178 in gold, $99,202,886 in silver, $4,917,960 in copper, $56,374,893 in lead, and $4,951,107 in zinc. The total amount of the dividends from the district for the period 1870–1917 is $43,544,700.

Mine production in Park City mining region, Utah, 1916–17.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	20	300,598	$111,236	2,900,718	1,512,578	33,233,794	5,136,353	$5,373,405
1917	17	240,610	110,647	2,937,438	1,285,308	33,715,565	5,201,756	6,312,103
Increase or decrease, 1917		−59,988	−589	+36,720	−227,270	+481,771	+65,403	+938,698
Total, 1870–1917			4,367,178	135,199,810	31,028,556	1,252,444,864	66,191,185	169,814,024

The output in 1917 was 240,610 tons, as against 300,598 tons in 1916. The crude ore shipped directly to the smelters consisted of mixed lead carbonates and sulphides aggregating 60,757 tons and contained 3,533.10 ounces of gold, 2,115,183 ounces of silver, 768,909 pounds of copper, and 20,282,892 pounds of lead, valued in all at $3,770,187, or an average value per ton of $62.05. The remainder of the ore (114,483 tons) was milled, the bulk of it producing 35,489 tons of concentrates, including those from 65,370 tons of creek tailings. The concentrates contained 1,819.45 ounces of gold, 822,255 ounces of silver, 516,399 pounds of copper, 13,432,673 pounds of lead, and 5,201,756 pounds of zinc, valued in all at $2,541,915, or an average value per ton of $71.63. In 1916 the average value per ton of shipping ore was $62.60 and of concentrates $70.64.

During 1917 the Silver King Coalition mine and mill were operated steadily, and crude lead ore and lead concentrates shipped aggregated nearly 29,000 tons. The company distributed in dividends $729,660 in 1917, which, added to dividends paid in the past from all its holdings, makes a total of $15,064,545.

The Ontario mine[1] in recent years has been in the hands of lessees most of the time who worked the upper levels, mining little ore but shipping large quantities of the old fillings. In 1917 the company reported ore sales amounting to $315,158, and gives the following notes:

> During the earlier part of the year the shaft was retimbered and the 1,700-foot level was unwatered and reopened. Shipments from stopes on the 1,700-foot level were started in April in a small way. The ore body, which was struck on the 1,600-foot level during 1916, was prospected by about 500 feet in drifts and 175 feet in raises. This development has shown a large amount of mineralization with varying values, the larger part of the material developed being too low grade to be treated profitably under present conditions. * * *
> A large tonnage has been shipped by the company during the past year, much of it low-grade ore on which there was but a small margin. This included a low-grade product from old fillings and old dumps. It is estimated that a considerable amount of ore of this character remains.

At this writing (March, 1918) the Ontario management reports that the ore on the 1,600-foot level has increased greatly in value and that a good body of ore has been found on the 1,700-foot level.

The Silver King Consolidated property[2] was equipped with a concentration plant having a capacity of 50 to 70 tons per day and produced during 11 months of 1917 ore and concentrates aggregating 10,260 tons, against 10,082 tons for the preceding 12 months. In 1917 the output contained 451,627 ounces of silver, 5,016,627 pounds of lead, 403 ounces of gold, and 248,771 pounds of copper. The net smelter returns amounted to $642,467 and dividends to $383,287. The output in 1917 compared well with the full year of 1916.

In December the California & Comstock property was purchased by the Silver King Consolidated, thus adding 135 acres of mineral territory equipped with a 125-ton milling plant, hoisting works, and necessary buildings. This ground has a production record of many thousand tons of ore near the surface, and in 1917 it was again a producer of milling ore which yielded lead concentrate containing silver with a little copper and zinc. These properties are to be developed by the Spiro tunnel, which, at the close of 1917, was 5,000 feet from its portal and progressing at the rate of 10 feet a day. The company report says:

> A total distance of about 15,000 feet will place it directly under the Comstock shaft at a depth of about 1,730 feet below the surface. The tunnel is 6 feet wide at the top by 7 feet 4 inches wide at the bottom, by 7 feet high inside of the timbers. It is perfectly straight, with a grade of 0.03 per cent, and is well equipped with an ample ditch, air pipes, and heavy rails. The tunnel crosses the strike of the sediments at an acute angle. It started in the Thaynes formation, but has not passed a considerable distance into the Woodside shales. It is expected to pass through the Woodside shales and into the Park City formation before reaching the California-Comstock ground.

The Daly-Judge property attracted considerable attention in the completion and operation of its electrolytic zinc plant, which began the production of high-grade spelter in February, 1917. According to the annual report of the company,[3] the total output of ore from the mine was 65,427 tons, dry weight, which is 524 tons less than the output of 1916. The report continues with the following paragraphs:

---

[1] Ontario Silver Mining Co. Ann. Rept. for the year ending Dec. 31, 1917.
[2] Silver King Consolidated Mining Co. Ann. Rept. for 11 months ending Dec. 31, 1917.
[3] Judge Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1917.

> One gratifying feature is the comparison of the increased production of 3,083 tons of crude or smelting grade ore over that of 1916, being 7,247 tons as against 4,164 tons. The products from the concentrating mill were 11,736 tons of lead concentrates and 5,470 tons of zinc concentrates, the latter being the product treated in our zinc reduction plant. The metal contents of all products sold, follow: 585,680 ounces of silver, 531.5 ounces gold, 7,919,720 pounds lead, 428,000 pounds copper, and 976,406 pounds of recoverable zinc. * * *
>
> The total receipts from all sources were $992,863.59, against expenditures of $934,313.69, which, together with our dividend payment of $480,000, has reduced our available cash balance to $133,839.71.

Average content of crude ore and concentrates of Judge Mining & Smelting Co., Utah, in 1917.

Kind of material.	Dry ore.	Gold (per ton).	Silver (per ton).	Copper.	Lead.	Zinc.	Iron.	Sold for—
	Short tons.	*Fine ounce.*	*Fine ounces.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Crude ore shipped	7,247	0.023	35.18	1.10	14.26	....	9.18	$36.38
Lead concentrates shipped	11,736	.029	26.62	1.03	24.59	....	20.00	54.44
Zinc concentrates shipped	926	.020	19.86	1.30	4.30	43.11	....	36.32

The Three Kings property continued development by crosscutting and sinking from the 500-foot level. At the American Flag mine some lessees mined ore. Both the Big Four and Broadwater concentration mills, working on tailings, were closed in September. Other producers were the New Quincy, Naildriver, and California-Comstock.

TOOELE COUNTY.

The production of 132,048 tons of ore by 61 producers in 1917, was 7,353 tons greater than the output by 48 producers in 1916. The average value per ton of the ore increased from $23.48 in 1916 to $24.64 in 1917, and the value per ton in gold and silver from $4.82 to $5.19. The total value of the ore sold or treated, containing gold, silver, copper, lead, and zinc, was $3,253,492, against $2,928,420 in 1916. The county output consisted of 1,564.64 ounces of gold, valued at $32,344; 793,265 ounces of silver, valued at $653,650; 4,181,231 pounds of copper, valued at $1,141,476; 15,031,521 pounds of lead, valued at $1,292,711; and 1,306,974 pounds of recoverable zinc, valued at $133,311. The increases were: Gold, $13,462; and copper, 1,344,553 pounds in quantity and $443,653 in value. The decreases were: Silver, 91,138 ounces in quantity, but an increase of $71,713 in value; lead, 3,696,150 pounds in quantity, but an increase of $502 in value; and zinc, 1,212,198 pounds in quantity and decrease of $204,258 in value.

There were 82,455 tons of crude shipping ore of various kinds. The zinc ore produced was 2,149 tons, all of which was of shipping grade and an oxidized product. The quantity of dry or siliceous ore decreased from 823 tons in 1916 to 263 tons in 1917. The output of copper ore of shipping grade was 30,466 tons, nearly all of which was oxidized, and the lead ore was 43,922 tons, of which there were 9,309 tons oxidized and 34,613 tons sulphides. There were also 5,583 tons of copper-lead ore. The crude ore shipped directly to the smelters contained $30,071 in gold, 630,504 ounces of silver, 3,600,215 pounds of copper, 11,201,922 pounds of lead, and 1,300,969 pounds of recoverable zinc, having a total value of $2,628,528, or an average value per ton of $31.88. Concentrating and jigging plants produced 13,898 tons of concentrates from the treatment of 38,472 tons of ore and yielded $2,118 in gold, 160,744 ounces of silver, 563,578 pounds of copper, 3,749,709 pounds of lead, and 6,005 pounds of recoverable zinc, valued in all at $611,515, or an average value per ton of $44.

Blue Bell district.—The R. E. P. property yielded a small quantity of lead sulphide ore carrying some silver.

Clifton district.—Seventeen producers in 1917 shipped 33,960 tons of ore, all of which went directly to the smelters and contained $11,665 in gold, 161,204 ounces of silver, 1,894,731 pounds of copper, 513,929 pounds of lead, valued in all at $705,957, or an average value per ton of $20.79. The principal part of the production came from the Gold Hill property of the Western Utah Copper Co., which shipped oxidized copper ore and oxidized lead ore to the smelters near Salt Lake City. The Woodman property was also a producer of copper and lead ore, both oxidized, carrying gold and silver values, and containing an average of about 9 per cent of iron and 51 per cent of silica. Other producers of more than 100 tons of ore were the Copperopolis, Garrison Monster, and Pole Star.

At the Western Utah property[1] the principal production and development in 1917 were confined to the Gold Hill group. There were shipped 28,718 tons of copper ore and 3,305 tons of lead ore, containing altogether 70 ounces of gold, 150,767 ounces of silver, 371,418 pounds of lead, and 1,710,984 pounds of copper. From ore sold to the smelters the sum of $470,477.73 was received. The company's report says:

> The greatest part of development work done during the year has been done toward the surface from the 80-foot level, on the 110-foot level, and on the 300-foot and 400-foot levels.
>
> On the 80-foot level and for some distance above and below this level the largest copper ore body occurred. In the regular course of mining this body of ore there was found quite a large tonnage of hematite iron in the core or center. This carried less than 1 per cent copper and reduced the ore reserves very materially. Late developments, however, on the 110-foot level show a very good grade of copper ore, which partly makes up for the large body of hematite described above.
>
> Quite a tonnage of silver-lead ore of low grade has been developed on the 300-foot and 400-foot levels.
>
> A small tonnage of lead-silver ore of very good grade has been developed on the 110-foot level.

Tungsten and molybdenum ores were produced from the Seminole property, though little of the latter ore was shipped. Oxidized bismuth ore in less than carload lots was shipped from the Wilson Consolidated property.

Columbia district.—The Old Sharp mine and the New Erie property produced a total of 1,016 tons of lead ore carrying a little silver.

Dugway district.—There was considerable activity in the district in 1917, but only a small quantity of ore was marketed. Certain promoters promised that a copper smelter would be in operation before the close of 1917, but at this writing (August, 1918) not even the necessary funds have been raised to purchase the equipment.

---

[1] Western Utah Cooper Co. First Ann. Rept., for year ending Dec. 31, 1917.

There were three properties producing, of which two, the Dugway and American Leasing, shipped copper ore, and the Laurel shipped a car of 50 per cent lead ore.

Erickson district.—Four properties reported the production of ore, the principal part coming from the Happy Jack, Indian Springs, and O. K. Silver properties.

Free Coinage district.—The Last Chance property yielded a carload of oxidized lead ore in 1917.

Lakeside district—The Monarch property, under option to one of the smelting companies in the Salt Lake Valley, produced lead ore averaging about 1 ounce of silver to the ton. This property has been opened by several tunnels, incline shafts, and drifts, all of which are said to be in ore, though most of its is too low grade to ship at a profit. The fissure in which the ore occurs is over 40 feet wide, and samples taken across its entire face show it to be a lead-silver ore of fine milling grade. The ore is hauled 7 miles north of the property to Delle, on the Western Pacific Railroad, and is shipped to a smelter.

North Tintic district—The improvement in zinc prices was the cause of an important production of ore from the Scranton mine, which also shipped some lead ore. The total output of the district amounted to 4,738 tons of lead and zinc ores.

Ophir district—Fifteen producers reported 80,944 tons of ore, which included 10,402 tons of old tailings re-treated. Half of the ore produced from the mines was milled and produced concentrates. There were shipped directly to the smelters 36,074 tons of crude ore, which included 891 tons of zinc ore containing 567,523 pounds of recoverable zinc. The principal producers of the district were the Cliff, Ophir Coalition, Hidden Treasure, and Ophir Hill. There were also shipments from the Buffalo Consolidated, Commodore, Eureka Ophir, Kearsarge, Chloride Point, Mono, Thad Stevens, and Utah Queen mines.

Rush Valley district—There were 10 producers reporting 10,713 tons of ore, including 719 tons of slag cleaned up from the old smelter operations. There were 5,590 tons of ore shipped directly to the smelters, and 4,004 tons were milled and yielded lead concentrate carrying a little copper and good silver values. The total output contained $14,647 in gold, 79,797 ounces of silver, 43,335 pounds of copper, 3,315,077 pounds of lead, and 56,490 pounds of recoverable zinc, valued in all at $383,089, or an average value per ton of $35.76. The Bullion Coalition was the principal producer of the milling ore and of more than half the ore shipped directly to the smelters. Reports of production were also received from the Cyclone, Galena King, Muerbrook, New Stockton, and Southport properties.

Silver Islet district.—Small outputs of lead ore containing a little copper and silver were reported from three properties in 1917.

Third Term district.—An important quantity of oxidized lead ore was shipped from the Third Term mine, an old property worked in the seventies. This ore was hauled by wagon to the smelter near Tooele.

UINTA COUNTY.

Carbonate district.—From the Kate lode on Grizzly Mountain, near Vernal, lead ore was shipped to the smelters, and 51 per cent copper ore was shipped from the Uinta Bonanza claim.

UTAH COUNTY.

Sixteen operators reported the production of 32,273 tons of ore in 1917, against 18,111 tons of ore produced by 18 operators in 1916. The total value of the output in 1917 was $1,064,457, against $703,569 in 1916. The total average value per ton of the ore decreased from $38.85 in 1916 to $32.98 in 1917, and the gold and silver value per ton increased from $12.60 to $16.64. Most of the ore produced (25,460 tons) was of shipping grade, and the remainder (2,874 tons) was milled and produced concentrate containing gold, silver, copper, and lead. There were also 3,939 tons of ore containing gold, silver, and copper treated at the Silver City mill.

American Fork district.—Seven producers reported 3,610 tons of ore, containing $2,004 in gold, 35,021 ounces of silver, 15,630 pounds of copper, and 641,990 pounds of lead, valued in all at $90,339, or an average value per ton of $25.02. The largest part of the ore produced was milled and yielded a lead concentrate, which, with 736 tons of crude ore, was shipped directly to the smelters. A small mill erected to treat lead ore produced from the Pacific property was replaced in 1917 by a larger plant nearer the mine. Ore produced from the Dutchman mine, operated by the same interests, was treated in the new mill. Lead ore was also produced from the Yankee, the Bay State, and the old Miller property.

The Fissures Exploration Co., operating the Pacific mine, increased its mill capacity, and toward the end of 1917 was treating 150 tons of ore a day. The Pacific fissure was drifted upon for 700 feet. The ore fissure is about 8 feet wide and has a proved depth of 300 feet. The Miller Hill property, adjoining the Pacific, started a new adit which was driven over 2,000 feet and will give a depth of 500 feet under old workings.

Mine production in American Fork district, Utah, 1916–17.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	6	868	$895	48,360	31,189	250,460	27,319	$ 61,332
1917	7	3,610	2,004	35,021	15,630	641,990	....	90,339
Increase or decrease, 1917		+2,742	+1,109	−13,339	−15,559	+391,530	−27,319	+29,007
Total, 1870–1917		64,217	371,373	1,887,596	159,091	28,586,796	46,911	3,895,050

Provo district.—A small shipment of lead ore was reported from the Monarch property in 1917.

Santaquin district.—From the Delsa property, one shipment of lead ore was made in 1917. Development work only was carried on at the Union Chief, which was a producer the preceding year.

Tintic district.—In 1917 the producers on the Utah County side were the Colorado Consolidated, May Day, Sioux, Tintic Standard, Uncle Sam, Utah Consolidated, and Yankee properties. The production of the district is reviewed under Juab County, under which the operations of the more important properties in 1917 are described.

WASHINGTON COUNTY.

Bull Valley district.—A small quantity of copper ore was shipped from one property in 1917. Work on the gold properties was practically abandoned during the year, there being no development performed beyond annual assessment work.

Harrisburg district.—The Adah property yielded a carload of oxidized copper ore in 1917.

Tutsagubet district.—Renewed operations by lessees at the Apex mine, owned by the Utah Southern Mining Co., resulted in an output of oxidized copper ore, which was shipped directly to the smelters in the Salt Lake Valley.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN CALIFORNIA.

(MINES REPORT.)

By Charles G. Yale.

INTRODUCTION.

Notwithstanding the increase in the cost of labor and supplies due to the war and the consequent closing down of smaller properties and curtailment of the operations of larger ones the output of the metal mining industry of California shows a decrease in value of only a little more than $2,000,000 in 1917 as compared with 1916. The gold, silver, copper, and zinc mines of the State made a smaller output, and the lead-producing mines made a larger output in both quantity and value. Metal mines of all kinds have been short of skilled labor, many men having been called into the Army or Navy and many others having quit mining to engage in other industrial occupations that brought higher remuneration. These conditions have affected the metal-mining industry of the State very materially, and the operators have been compelled to employ much less efficient labor.

California, as a metal-producing State, has always been best known as the leader in output of gold, a position it has annually maintained for about 70 years, except in a few years. The gold-mining industry of the State has, however, now entered a condition of temporary decadence. There was a material decline in 1916 as compared with 1915, and the decline in 1917 from 1916 is still more marked—amounting to $1,323,237. Owing to the exigencies of the war skilled labor became much scarcer and more expensive, so that operations were curtailed, especially in the larger deep mines. Materials and supplies were scarcer and more expensive, so that many of the smaller and less profitable mines were compelled to cease operations. This condition naturally brought about a reduction in the number and output of the mines. Many miners working for themselves or for wages quit gold mining and began to search for chrome, manganese, magnesite, and tungsten or to work in mines of those minerals.

The decrease in the production of gold in California is due entirely to the reduction in the output of the deep mines, for the placers, particularly the dredges, have made a larger output. The production of the deep mines in 1917 decreased more than 14 per cent, whereas that of the placers increased nearly 6 per cent. The gold recovered from placers in 1917 was about 45 per cent of the total output of the State. Of this placer output the gold dredges produced 91 per cent. Since the beginning of the gold-dredging industry in California in 1898, the gold recovered from this source to the end of 1917 has been $95,193,995. Before gold dredging was begun the placer mining had been steadily declining and it was asserted that placer mining in California was virtually at an end. Yet, these dredges produced 41 per cent of the total production of gold in 1917, and thus far, have shown no diminution of product, although the output of one of the larger fields is declining because so much ground has been worked out. Meantime the other large fields continue production, and at numerous isolated sections dredges have been profitably engaged. There are now 55 gold dredges in operation in California, or 5 less than in 1916.

The number of producing gold mines in the State has been gradually reduced until there are now only about 500. It is expected that this number will continue to decrease during 1918 and until the war is over and normal conditions are resumed. Many mines, especially on the Mother Lode, have been working on such a narrow margin of profit that increased costs have nearly or entirely wiped this margin out, so that gold mining is no longer an attractive industry in California. There was a scarcity of water both for power and for washing gravel during the year owing to the prevalent " dry season " in California. This shortened the period during which gravel could be washed in placers and compelled the " hanging up " of part of the stamps in quartz mills. The falling off in the purchasing power of gold has also been a serious matter, and with high costs in all directions the operators consider that their gold only brings them $10 to $12 an ounce, as compared with several years ago. The cost per ounce in the production of gold has steadily advanced, and in some cases has reached $14 to $16, as compared with an average of $12 three years ago.

Another serious complaint made by the drift and quartz miners is the insistence of the War Department on the construction of concrete dams for the impounding of tailings, when formerly timber dams sufficed or none at all were required. It is argued by the miners that at a time when everything required in construction work is so expensive and costs of labor are excessive, the burden added by the construction of such concrete dams in nonnavigable streams might well be postponed during the war. Many of these dams and impounding works cost $25,000 or $30,000 each, and in some places the expense has become prohibitive and the mines involved have ceased operation. In a large section of Butte County, for example, every drift mine, even those already having timber dams, has ceased operations for the present at least, and some have been abandoned entirely and the plants removed. This condition has materially affected quartz-mining interests on portions of the Mother Lode, a long distance from any navigable streams.

The only counties in California showing an increased output of gold in 1917 were Amador, Calaveras, Del Norte, Fresno, Humboldt, Nevada, Placer, Sacramento, Trinity, and Yuba. The combined increase of these counties was only a little more than a million dollars, of which Yuba County contributed about half from its dredges. The other counties had a combined decrease of $2,344,194, so that the total decrease in gold output for the year was $1,323,237, or about 6 per cent.

The other metals produced in the State were also affected by some of the existing conditions mentioned in connection with gold mining. The silver yield fell off 13 per cent in value; the copper was less by 14 per cent in quantity and 4 per cent in value; and the zinc was less by 29 per cent in quantity and 46 per cent in value. The only metal showing an increase was lead, which increased in quantity 76 per cent and in value 119 per cent. The total combined value of all the metals was $37,685,985, or 5 per cent less in 1917 than in 1916. A little more than 3,000,000 tons of ore from deep mines of all classes was treated in 1917, with an average value in all metals of $9.52 a ton, which average differs little from that of 1916.

The details of mining work in the Mother Lode counties are given in the section on production by counties. A condensed statement is given in the following table:

Gold and silver produced at mills in Mother Lode counties in California in 1917.

County.	Ore treated (short tons).	Gold and silver recovered in bullion.		
		Gold.	Silver (fine ounces).	Average value in gold and silver per ton of ore.
Amador	798,952	$2,223,613	17,044	$2.800
Calaveras	352,641	473,205	4,720	1.353
Eldorado	2,506	3,057	32	1.230
Mariposa	41,548	268,471	2,387	6.509
Tuolumne	41,256	233,866	8,550	5.839
	1,236,903	3,202,212	32,733	2.610

County.	Concentrates produced.				Value of total recovery.	
	Quantity (short tons).	Gold.	Silver (fine ounces).	Average value in gold and silver per ton of concentrates.	Total.	Average per ton of ore.
Amador	18,456	$1,422,404	8,608	$77.45	$3,667,154	$4.589
Calaveras	[a] 26,299	349,574	4,734	[a] 13.44	830,569	[b] 2.355
Eldorado	66	2,543	2	38.57	5,628	2.245
Mariposa	711	41,008	982	58.81	312,255	7.515
Tuolumne	1,585	73,432	890	46.79	315,076	7.637
	47,117	1,888,961	15,216	[c] 40.35	5,130,682	4.148

[a] Includes 17,875 tons of concentrates from copper ores concentrated; exclusive of copper concentrates the average recovery was $41.96 a ton.

[b] Exclusive of copper ores concentrated.

[c] Average value exclusive of copper concentrates was $65.03 a ton.

A comparison of this table with the corresponding one for 1916 shows a total decrease in ore treated at gold and silver mills in the five Mother Lode counties in 1917 of 156,885 tons. Each of these counties shows more or less decrease of tonnage except Amador, which increased its output of ore by 68,854 tons.

In the Mother Lode counties in 1917 there were treated at gold and silver mills 1,236,903 tons of ore, yielding in gold and silver $5,130,682, or an average of $4.148 per ton, as compared with 1,393,788 tons in 1916, yielding $5,853,618, and averaging $4.199 a ton; as compared with 1,521,847 tons in 1915, yielding $6,349,772, and averaging $4.17 a ton; 1,243,529 tons in 1914, yielding $5,075,522, an average of $4.08 a ton; 1,242,343 tons in 1913, yielding $4,728,450, an average of $3.81 a ton; 1,299,988 tons in 1912, yielding $4,803,935, or $3.69 a ton; and 1,377,084 tons in 1911, yielding $4,910,358, or $3.57 a ton.

The average value of gold and silver in the concentrates per ton was $40.35 in 1917, as compared with $56.83 in 1916, and $56.56 in 1915. Excluding copper concentrates the average value per ton was $65.03 in 1917. There was 47,117 tons of concentrates obtained from the 1,236,903 tons of siliceous milled ore and 148,078 tons of copper ore concentrated in these counties in 1917.

The total quantity of ore treated at gold and silver mills from the deep mines of the State in 1917 was 1,809,017 short tons, which was 288,120 tons less than in 1916. Of the total ore milled, 68 per cent came from the Mother Lode counties in 1917. Amador, the largest producer of the Mother Lode counties, produced 44 per cent of the total quantity of ore milled in the State in 1917, and 65 per cent of the ore milled in the Mother Lode counties.

Crude ore sold or treated in California in 1917, in short tons.

County.	Siliceous ores.	Copper ores.	Lead and lead-zinc ores.	Silver ores.	Silver-lead ores.	Zinc ores.	Total.
Amador	804,852	23					804,875
Butte	349						349
Calaveras	407,700	189,124					596,824
Del Norte, Humboldt, Riverside, Sacramento, and San Diego [a]	515	70					585
Eldorado	2,506						2,506
Fresno	601						601
Imperial	154						154
Inyo	2,169	382	27,714		53,954	135	84,354
Kern	123,140	2,417		92			125,649
Madera	2,111	4,119					6,230
Mariposa	41,690	186					41,876
Mono	18,776						18,776
Nevada	480,869						480,869
Placer	14,080	2,574					16,654
Plumas	13,879	176,094					189,973
San Bernardino	1,165	20,630	366	77	10,045		32,283
Shasta	9,673	484,511		285			494,469
Sierra	50,042						50,042
Siskiyou	2,237	3,616					5,853
Trinity	186	8,615					8,801
Tuolumne	41,309	218					41,527
	2,018,003	892,579	28,080	454	63,999	135	3,003,250
Increase or decrease	−174,010	−41,143	+26,444	+389	+32,872	[b]−28,944	−184,392
Average value per ton in gold and silver	$5.133	$1.565	$4.937	$13.32	$8.621	$0.171	$4.146

[a] Yield of single mine in each county combined to conceal separate output.
[b] Considerable quantity of ore classed as lead and lead-zinc ores.

Value of ore mined and treated in California in 1917.

Class.	Ore.	Total value.		Average value per ton.	
	Quantity (short tons).	In gold and silver.	In all metals.	In gold and silver.	In all metals.
Siliceous	2,018,003	$10,359,517	$10,380,060	$5.133	$5.143
Copper	892,579	1,396,972	14,871,637	1.565	16.661
Lead	28,080	138,631	1,129,811	4.937	40.235
Silver	454	7,048	8,176	13.32	18.239
Silver-lead	63,999	551,778	2,187,900	8.621	34.186
Zinc	135	23	11,911	.1717	88.230
	3,003,250	12,453,969	28,589,495	4.146	9.519

The value of all metals obtained from ores mined and treated in California in 1917 (not including placer mine output) was $28,589,495, an average of $9.52 a ton. In 1916 the value was $31,154,122, an average of $9.77 a ton; in 1915 it was $23,636,028, an average of $7.87 a ton. In 1914 the figures, respectively, were $16,610,509 and $6.74; in 1913, $17,954,941 and $7.19; in 1912, $17,716,357 and $6.71; in 1911, $16,167,193 and $5.49; in 1910, $18,109,008 and $6.71; and in 1909, $19,715,314 and $6.48.

Gold and silver produced in California in 1917, by methods of treatment.

County.	Ore to gold and silver mills.			Ore to concentrating mills.	Concentrates produced.		
	Quantity.	Gold.	Silver.	Quantity.	Quantity.	Gold.	Silver.
	Short tons.		*Fine ounces.*	*Short tons.*	*Short tons.*		*Fine ounces.*
Amador	798,962	$2,223,613	17,044	....	18,456	$1,422,404	8,608
Butte	140	1,751	5	....	....	....	....
Calaveras	352,641	473,205	4,720	148,690	26,299	349,574	4,734
Del Norte, Humboldt, Riverside, Sacramento, and San Diego[1]	193	1,902	6	....	6	930	9
Eldorado	2,506	3,057	32	....	66	2,543	2
Fresno	119	1,265	4	....	....	....	....
Inyo	9,709	29,808	682	....	201	21,354	10,053
Kern	123,140	532,880	5,949	....	20	1,988	118
Madera	2,111	11,065	52	....	41	3,488	6
Mariposa	41,548	268,471	2,387	....	711	41,008	982
Mono	18,090	203,416	5,186	....	....	....	....
Nevada	337,596	3,292,110	34,432	....	1,096	54,175	2,238
Placer	14,080	89,340	1,573	....	117	8,765	667
Plumas	13,870	51,326	835	172,306	12,409	25,902	80,848
Shasta	864	17,196	159	101,173	13,391	2,835	2,393
Sierra	49,779	320,728	1,769	....	1	343	1
Siskiyou	2,237	17,095	234	....	2	196	1
Trinity	186	2,366	23	....	8	589	11
Tuolumne	41,256	233,866	8,550	....	1,585	73,432	890
	1,809,017	7,774,455	83,142	422,169	74,409	2,009,526	111,561
Average value per ton	....	$4.297	$0.038	....	....	$27.00	$1.235

County.	Crude ore to smelter.			Old tailings treated.		
	Quantity.	Gold.	Silver.	Quantity.	Gold.	Silver.
	Short tons.		*Fine ounces.*	*Short tons.*		*Fine ounces.*
Amador	23	....	12	5,900	$11,990	233
Butte	209	$2,905	258	....	....	....
Calaveras	40,503	65,660	94,774	54,990	65,435	110
Del Norte, Riverside, and San Diego[1]	392	....	84	....	....	....
Fresno	482	1,993	340	....	....	....
Imperial	154	919	6	....	....	....
Inyo	74,645	74,237	638,050	....	....	....
Kern	2,509	1,984	3,411	....	....	....
Madera	4,119	3,797	533	....	....	....
Mariposa	328	2,481	535	....	....	....
Mono	....	....	....	686	5,624	1,686
Nevada	....	....	....	143,273	320,292	26,792
Placer	2,574	22,180	12,964	....	....	....
Plumas	3,797	1,511	9,039	....	....	....
San Bernardino	31,283	152,766	107,394	1,000	1,310	528
Shasta	392,432	464,556	628,083	....	....	....
Sierra	170	1,634	5	93	580	2
Siskiyou	3,616	5,170	18,833	....	....	....
Trinity	8,615	17,901	9,788	....	....	....
Tuolumne	218	....	....	53	4,568	11
	566,069	819,694	1,524,109	205,995	409,799	29,362
Average value per ton	....	$1.448	$2.218	....	$1.989	$0.117

[1] Yield of single mine in each county combined to conceal separate output.

In 1917 there was treated at gold and silver mills and at concentrating plants 2,231,186 tons of ore yielding altogether $9,783,981 in gold and 194,703 fine ounces of silver, valued at $160,435, a total value of $9,944,416 in gold and silver and an average value per ton of $4.46 in both metals. The average value in 1916 was $5.04; in 1915, $5.56; in 1914, $5.44; in 1913, $5.57; in 1912, $5.08; in 1911, $4.64; in 1910, $5.25; and in 1909, $4.88.

There was recovered in 1917 as bullion in mills $7,774,455 in gold and 83,142 fine ounces of silver, valued at $68,508, a total of $7,842,963 in gold and silver and an average of $4,33 in both metals. From 1,809,017 tons of gold milling ore and 422,169 tons of concentrating ores, 74,409 tons of concentrates were obtained, containing $2,009,526 in gold and 111,561 fine ounces of silver, valued at $91,927. There was a yield of gold and silver of $2,101,453 recovered from the concentrates, or an average of $28.24 a ton.

Of smelting ores 566,069 tons were treated having an output of gold of $819,694, and of 1,524,109 fine ounces of silver, valued at $1,255,865. The total yield of gold and silver was $2,075,559, or an average of $3.67 a ton.

There were treated also 205,995 tons of tailings, yielding $409,799 in gold and 29,362 ounces of silver, valued at $24,195. The total gold and silver produced from tailings was valued at $433,994, an average of about $2.11 a ton.

PRODUCTION.

GENERAL STATEMENT.

Gold, silver, copper, lead, and zinc produced in California, 1907–1917.

Year.	Number of mines producing.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.	*Value.*	*Fine ozs.*	*Pounds.*	*Pounds.*	*Pounds.*	
1907	1,061	2,054,653	$16,727,928	1,138,858	28,528,020	2,625,419	233,550	$23,338,104
1908	1,054	2,546,908	18,761,559	1,647,278	38,776,881	1,237,548	....	24,805,141
1909	1,127	3,041,688	20,237,870	2,098,253	57,288,281	1,502,597	....	28,841,050
1910	1,079	2,697,885	19,715,440	1,840,085	48,700,756	2,870,977	....	27,020,405
1911	1,181	2,797,261	19,738,908	1,270,445	36,316,136	1,398,111	2,807,035	25,174,677
1912	1,041	2,641,497	19,713,478	1,300,136	33,451,672	1,144,731	4,345,591	26,383,946
1913	796	2,495,958	20,406,958	1,378,399	34,575,007	3,514,342	1,057,485	26,812,487
1914	658	2,465,485	20,653,496	1,471,859	30,507,692	4,251,923	389,471	25,710,645
1915	608	3,002,779	22,442,296	1,678,756	40,751,625	4,579,245	13,094,032	32,263,844
1916	589	3,187,642	21,410,741	2,564,354	55,897,118	12,407,493	15,256,485	39,749,263
1917	490	3,003,250	20,087,504	1,775,431	48,153,139	21,868,628	10,872,716	37,685,985
Increase or decrease, 1917	−99	−184,392	−1,323,237	−788,923	−7,743,979	+9,461,135	−4,383,769	−2,063,278

In 1917 there were 490 properties reporting production in California, of which 241 were deep mines and 249 placers. The producing deep mines of 1917 may be classified by chief metallic product as follows: Gold, 145; copper, 48; silver, 3; silver-lead, 24; lead, 19, and zinc, 2. Of the placer mines 71 were hydraulic, 16 less than in 1916; 55 were dredges, 5 less than in 1916; 53 were drift, 14 less than in 1916, and 70 were surface or sluicing mines, 8 less than in 1916. There were altogether 43 less placer mines producing than in 1916. Of the deep mines there were 59 less gold mines, 12 less copper, 2 more silver, 6 more silver-lead, and 1 less zinc; there were, therefore, 56 less deep mines producing in 1917 than in 1916. The dredges are enumerated by the number of boats at work, some companies operating only one and others several.

Mine production of gold, silver, copper, lead, and zinc in California in 1917.

County.	Ore treated.	Deep-mine gold.		Placer gold.		Total gold.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.	*Fine ounces.*		*Fine ounces.*		*Fine ounces.*	
Amador	804,875	176,956.09	$3,658,007	297.84	$6,157	177,253.93	$3,664,164
Butte	349	225.23	4,656	44,389.63	917,615	44,614.86	922,271
Calaveras	596,824	46,143.65	953,874	25,037.35	517,568	71,181.00	1,471,442
Del Norte	289	...	...	66.42	1,373	66.42	1,373
Eldorado	2,506	270.90	5,600	926.77	19,158	1,197.67	24,758
Fresno	601	157.61	3,258	120.31	2,487	277.92	5,745
Humboldt	73	77.01	1,592	1,039.77	21,494	1,116.78	23,086
Imperial	154	44.46	919	...	...	44.46	919
Inyo	84,354	6,065.93	125,394	...	...	6,065.93	125,394
Kern	125,649	25,970.21	536,852	48.38	1,000	26,018.59	537,852
Madera	6,230	887.68	18,350	27.28	564	914.96	18,914
Mariposa	41,876	15,091.06	311,960	64.63	1,336	15,155.69	313,296
Mono	18,776	10,112.31	209,040	...	...	10,112.31	209,040
Nevada	480,869	177,370.66	3,666,577	791.90	16,370	178,162.56	3,682,947
Placer	16,654	5,818.79	120,285	20,240.15	418,401	26,058.94	538,686
Plumas	189,973	3,809.00	78,739	2,574.32	53,216	6,383.32	131,955
Sacramento	120	59.99	1,240	92,799.74	1,918,341	92,859.73	1,919,581
San Bernardino	32,283	7,453.43	154,076	43.54	900	7,496.97	154,976
Shasta	494,469	23,441.90	484,587	14,054.78	290,538	37,496.68	775,125
Sierra	50,042	15,638.91	323,285	2,957.79	61,143	18,596.70	384,428
Siskiyou	5,853	1,086.55	22,461	14,661.93	303,089	15,748.48	325,550
Trinity	8,801	1,008.91	20,856	28,115.16	581,192	29,124.07	602,048
Tuolumne	41,527	15,086.52	311,866	445.97	9,219	15,532.49	321,085
Yuba	...	...	...	177,907.43	3,677,673	177,907.43	3,677,673
Merced, Riverside, San Diego, and Stanislaus [a]	103	...	...	12,345.11	255,196	12,345.11	255,196
	3,003,250	532,776.80	11,013,474	438,956.20	9,074,030	971,733.00	20,087,504
Total, 1916	3,187,642	620,897.19	12,835,084	414,847.40	8,575,657	1,035,744.59	21,410,741
Increase or decrease	−184,392	−88,120.39	−1,821,610	+24,108.80	+498,373	−64,011.59	−1,323,237

County.	Deep-mine silver.		Placer silver.		Total silver.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*		*Fine ounces.*	
Amador	25,897	$21,339	23	$19	25,920	$21,358
Butte	263	217	3,367	2,774	3,630	2,991
Calaveras	104,339	85,975	2,438	2,009	106,777	87,984
Del Norte	...	...	10	8	10	8
Eldorado	34	28	69	57	103	85
Fresno	344	283	7	6	351	289
Humboldt	4	3	112	92	116	95
Imperial	6	5	...	...	6	5
Inyo	648,785	534,599	...	...	648,785	534,599
Kern	9,478	7,810	4	3	9,482	7,813
Madera	591	487	2	2	593	489
Mariposa	3,904	3,217	5	4	3,909	3,221
Mono	6,871	5,662	...	...	6,871	5,662
Nevada	63,462	52,293	51	42	63,513	52,335
Placer	15,204	12,528	1,647	1,357	16,851	13,885
Plumas	90,222	74,343	143	118	90,365	74,461
Sacramento	11	9	5,434	4,478	5,445	4,487
San Bernardino	107,922	88,928	2	2	107,924	88,930
Shasta	630,635	519,643	1,286	1,060	631,921	520,703
Sierra	1,778	1,465	199	164	1,977	1,629
Siskiyou	19,068	15,712	1,421	1,171	20,489	16,883
Trinity	9,822	8,093	2,340	1,928	12,162	10,021
Tuolomne	9,450	7,787	25	21	9,475	7,808
Yuba	...	...	7,999	6,591	7,999	6,591
Merced, Riverside, San Diego, and Stanislaus [a]	84	69	673	554	757	623
	1,748,174	1,440,495	27,257	22,460	1,775,431	1,462,955
Total 1916	2,534,743	1,667,861	29,611	19,484	2,564,354	1,687,345
Increase or decrease	−786,569	−227,366	−2,354	+2,976	−788,923	−224,390

[a] Yield of single mine in each county combined to avoid disclosing separate output.

Mine production of gold, silver, copper, etc., in California in 1917—Continued.

County.	Copper.		Lead.		Zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Amador	2,381	$650			7,716	$787	$3,686,959
Butte							925,262
Calaveras	8,052,978	2,198,463	1,105	$95	1,833	187	3,758,171
Del Norte	30,000	8,190					9,571
Eldorado							24,843
Fresno	33,000	9,009					15,043
Humboldt							23,181
Imperial	7,000	1,911					2,835
Inyo	737,582	201,360	19,671,732	1,091,769	3,956,343	403,547	2,956,669
Kern	260,000	70,980					616,645
Madera	423,901	115,725					135,128
Mariposa	36,502	9,965					326,482
Mono							214,702
Nevada							3,735,282
Placer	633,747	173,013					725,584
Plumas	7,471,692	2,039,608					2,246,024
Sacramento							1,924,068
San Bernardino	1,572,125	429,190	2,195,791	188,838	45,216	4,612	866,546
Shasta	26,658,879	7,277,874			6,320,529	644,694	9,218,396
Sierra							386,057
Siskiyou	896,846	244,839			541,079	55,190	642,462
Trinity	1,304,901	356,238					968,307
Tuolumne	12,000	3,276					332,169
Yuba							3,684,264
Merced, Riverside, San Diego, and Stanislaus [a]	20,205	5,516					261,335
	48,153,139	13,145,807	21,868,628	1,880,702	10,872,716	1,109,017	37,685,985
Total, 1916	55,897,118	13,750,691	12,407,493	856,117	15,256,485	2,044,369	39,749,263
Increase or decrease	−7,743,979	−604,884	+9,461,135	+1,024,585	−4,383,769	−935,352	−2,063,278

[a] Yield of single mine in each county combined to avoid disclosing single output.

GOLD.

The total production of gold in California in 1917 was 971,733.00 fine ounces, valued at $20,087,504, a decrease of 64,011.59 fine ounces, valued at $1,323,237. The deep mines of the State yielded 532,776.80 fine ounces of gold, valued at $11,013,474. Of the deep mine gold 93 per cent was derived from siliceous ore, 6 per cent from copper ore, and the remainder from lead, silver-lead, and zinc ores.

While the production of gold from deep mines materially decreased, that from the placers increased $498,373, due mainly to larger returns from dredging operations. The dredges yielded $544,300 more in 1917 than in 1916. Since gold dredging began in California in 1898, the total output of gold from that source to the end of 1917 has been $95,186,985. Since 1898 the Oroville (Butte County) dredging field has yielded $30,160,486, not including $2,148,444 derived in the last eight years from adjacent districts in the same county. The Marysville (Yuba County) field has produced from 1903 to 1917, inclusive, $28,119,067 in gold; the Folsom (Sacramento County) field has yielded since 1902 from dredging, gold valued at $21,835,675. Quite a large number of dredges operated in various localities in other counties of the State, but their output of gold is not included in these figures relating to the more extensive dredge fields named. The placer yield of gold in 1917 in California was 438,956.20 fine ounces, valued at $9,074,030. The placer mines produced 45 per cent of the gold yield of 1917, and the deep mines 55 per cent, as compared with 40 per cent for the placers in 1916 and 60 per cent for the deep mines.

The dredges produced 41 per cent of the total gold yield from all sources in 1917. Of the total placer gold, the dredges produced 91.6 per cent, the hydraulic mines about 3 per cent, the drift mines 4 per cent, and the surface or sluicing mines 1.4 per cent. It is probable that this percentage from surface placers is too high, for in the reports received at the office of the United States Geological Survey large numbers of miners classify themselves as working placers without specifying the exact kind. Some of these may have been small hydraulic or drift mines instead of mere surface or sluicing mines. Although the three larger and more important dredging fields of the State are at Oroville, in Butte County; Folsom, in Sacramento County; and Marysville, in Yuba County, dredges are also operated in 7 other counties—5 in Calaveras, 1 in Merced, 3 in Placer, 3 in Shasta, 3 in Siskiyou, 1 in Stanislaus, and 4 in Trinity. The Yuba County dredges, 12 in number, made the largest output of gold in 1917, the value being $3,659,211, an increase of $519,061 as compared with 1916. Sacramento County with 12 dredges at work made an output of $1,913,504, an increase of $84,026. In Butte County (including Oroville and the "outside" districts) 11 dredges produced $893,141, or $317,733 less than in 1916. This statement shows that $285,354 more gold was obtained in these three districts in 1917 than in 1916, although one of them, the oldest, showed a material decrease.

Of the 26 counties producing gold in 1917 in California, 3 yielded no placer gold, and 4 yielded no gold from deep mines. Five counties produced more than $1,000,000 each in gold in 1917 as follows: Nevada, $3,682,947; Yuba, $3,677,673; Amador, $3,664,164; Sacramento, $1,919,581; and Calaveras, $1,471,442. The leading hydraulic mining county was Siskiyou; the greatest producer of gold from drift mines was Placer; the largest producer of gold from dredges was Yuba; and the largest producer of gold from surface or sluicing mines was Siskiyou. The largest increase—$509,950—in gold in 1917, as compared with 1916, was in Yuba County, which was followed by Trinity, with $166,555; Calaveras, $115,322; Placer, $110,286; Sacramento, $85,726; Nevada, $13,069; Medera, $8,608; Fresno, $5,052; Amador, $3,614; Humboldt, $1,807; and Del Norte, $968. The counties which showed a decreased output of gold in 1917, as compared with 1916, were as follows: Tuolumne, $547,152; Sierra, $339,828; Eldorado, $337,063; Butte, $334,960; Kern, $209,190; Shasta, $161,760; San Bernardino, $124,837; Siskiyou, $115,757; Mariposa, $88,422; Mono, $28,044; Imperial, $22,419; Modoc, $2.729; Stanislaus, $12,348; Plumas, $1,430; Riverside, $7,855; and Inyo, $6,328.

Mine production of gold in California in 1917, in fine ounces.

County.	Placers.	Deep mines.							Grand total.
		Siliceous ores.	Copper ores.	Lead ores.	Silver ores.	Silver-lead ores.	Zinc ores.	Total.	
Amador	297.84	176,956.09						176,956.09	177,253.93
Butte	44,389.63	225.23						225.23	44,614.86
Calaveras	25,037.35	42,923.38	3,220.27					46,143.65	71,181.00
Del Norte	66.42								66.42
Eldorado	926.77	270.90						270.90	1,197.67
Fresno	120.31	157.61						157.61	277.92
Humboldt	1,039.77	77.01						77.01	1,116.78
Imperial		44.46						44.46	44.46
Inyo		1,315.46	16.01	123.02		4,611.44		6,065.93	6,065.93
Kern	48.38	25,970.21						25,970.21	26,018.59
Madera	27.28	704.00	183.68					887.68	914.96
Mariposa	64.63	15,091.06						15,091.06	15,155.69
Mono		10,112.31						10,112.31	10,112.31
Nevada	791.90	177,370.66						177,370.66	178,162.56
Placer	20,240.15	4,745.83	1,072.96					5,818.79	26,058.94
Plumas	2,574.32	2,514.87	1,294.13					3,809.00	6,383.32
Sacramento	92,799.74	59.99						59.99	92,859.73
San Barnardino	43.54	150.45	7,244.01		6.97	52.00		7,453.43	7,496.97
Shasta	14,054.78	5,187.01	18,254.89					23,441.90	37,496.68
Sierra	2,957.79	15,638.91						15,638.91	18,596.70
Siskiyou	14,661.93	836.45	250.10					1,086.55	15,748.48
Trinity	28,115.16	142.95	865.96					1,008.91	29,124.07
Tuolumne	445.97	15,086.52						15,086.52	15,532.49
Yuba	177,907.43								177,907.43
Merced, Riverside, San Diego, and Stanislaus [a]	12,345.11								12,345.11
	438,956.20	495,581.36	32,402.01	123.02	6.97	4,663.44		532,776.80	971,733.00
Total, 1916	414,847.40	574,515.59	44,644.11	144.55		1,572.96	19.98	620,897.19	1,035,744.59
Increase (+) or decrease (−)	+24,108.80	−78,934.23	−12,242.10	−21.53	+6.97	+3,090.48	−19.98	−88,120.39	−64,011.59

[a] Yield of single mine in each county combined to avoid disclosing separate output.

Value and source of placer gold mined in California in 1917.

County.	Hydraulic.	Dredging.	Drift.	Surface placers.	Total.
Amador			$2,408	$3,749	$6,157
Butte		$893,141	13,984	10,490	917,615
Calaveras		499,785	12,378	5,405	517,568
Del Norte	$225			1,148	1,373
Eldorado			8,889	10,269	19,158
Fresno, Kern, Madera, and San Bernardino[a]				4,951	4,951
Humboldt	19,138			2,356	21,494
Mariposa				1,336	1,336
Merced and Stanislaus[b]		254,948		248	255,196
Nevada	7,019		9,351		16,370
Placer		131,250	269,087	18,064	418,401
Plumas	22,321		22,972	7,923	53,216
Sacramento		1,913,504	4,837		1,918,341
Shasta		282,239		8,299	290,538
Sierra	29,710		13,267	18,166	61,143
Siskiyou	101,920	182,855	101	18,213	303,089
Trinity	80,836	496,594	1,654	2,108	581,192
Tuolumne			7,111	2,108	9,219
Yuba	5,934	3,659,211	720	11,808	3,677,673
	267,103	8,313,527	366,759	126,641	9,074,030

[a] Yield of single mine in each county combined to avoid disclosing separate output.
[b] Yield of single dredge in each county combined to avoid disclosing separate output.

From the siliceous ore and tailings the recovery of gold by methods of treatment in California in 1917 was as follows: By amalgamation, 376,089.25 fine ounces, valued at $7,774,455; by cyanidation, 22,649.32 fine ounces, valued at $468,203; by chlorination, 9,100.74 fine ounces, valued at $188,129; from concentrates sent to smelters for treatment, 85,284.79 ounces, valued at $1,762,993. These figures are approximate only, as the smaller operators, many in number, keep no separate accounts and the larger companies do not always segregate the quantities of gold gained by separate systems of treatment.

The 249 productive placer mines in California in 1917 yielded gold valued at $9,074,030, and 27,257 ounces of silver, valued at $22,460, a total value of $9,096,490. The increase in placer gold was $498,373 and the increase in the value of silver was $2,976. In production of gold the dredge properties showed an increase of $544,300, the hydraulic mines a decrease of $122,912, the drift mines an increase of $115,462, and the surface or sluicing mines a decrease of $38,477.

SILVER.

The deep mine production of silver in California in 1917 was 1,748,174 ounces, valued at $1,440,495, a decrease in quantity of 786,569 ounces and in value of $227,366. The larger portion of the output, 1,524,109 ounces, valued at $1,255,865, was derived from crude smelting ores. Siliceous ores, milled and smelted, yielded 139,492 ounces, valued at $114,941. The largest output of silver in 1917 came from Inyo County (not from Shasta as has been usual for years), which produced from copper ores 661 ounces, valued at $545; from siliceous ore, 550 ounces, valued at $453; from lead ores, 164,115 ounces, valued at $135,231; from silver-lead ores, 483,431 ounces, valued at $398,347; and from zinc ores, 28 ounces, valued at $23. This makes a total yield of silver from Inyo County of 648,785 ounces, valued at $534,599. Shasta County followed Inyo in yield of silver, the output being 631,921 fine ounces, valued at $520,703, as compared with 1,695,245 ounces in quantity and $1,115,471 in value in 1916. The total silver derived from deep mines of all classes and from placer mines in California in 1917 was 1,775,431 ounces, valued at $1,462,955. The silver obtained from refining placer gold mined in the State in 1917 was 27,257 ounces, valued at $22,460. The largest producer of placer silver was Yuba County—7,999 ounces, valued at $6,591.

Silver, lead, and silver-lead mines are more numerous and productive since the advance in the price of silver. Silver derived from purely silver ores in 1917 amounted to 8,378 fine ounces, valued at $6,903. From 63,999 tons of silver-lead ores there was derived 552,641 fine ounces of silver, valued at $455,376, as well as $96,402 in gold; from 28,080 tons of lead ore was obtained 165,155 ounces of silver, valued at $136,088; and from 135 tons of zinc ore, the silver yield was 28 ounces, valued at $23.

Mine production of silver in California in 1917, by sources, in fine ounces.

County—	Placers.	Deep mines.							Grand total.
		Siliceous ores.	Copper ores.	Lead ores.	Silver ores.	Silver-lead ores.	Zinc ores.	Total.	
Amador	23	25,885	12	....	....	....	....	25,897	25,920
Butte	3,367	263	....	....	....	....	....	263	3,630
Calaveras	2,438	8,078	96,261	....	....	....	....	104,339	106,777
Del Norte	10	....	....	....	....	....	....	....	10
Eldorado	69	34	....	....	....	....	....	34	103
Fresno	7	344	....	....	....	....	....	344	351
Humboldt	112	4	....	....	....	....	....	4	116
Imperial	....	6	....	....	....	....	....	6	6
Inyo	....	550	661	164,115	....	483,431	28	648,785	648,785
Kern	4	6,067	....	....	3,411	....	....	9,478	9,482
Madera	2	58	533	....	....	....	....	591	593
Mariposa	5	3,540	364	....	....	....	....	3,904	3,909
Mono	....	6,871	....	....	....	....	....	6,871	6,871
Nevada	51	63,462	....	....	....	....	....	63,462	63,513
Placer	1,647	2,240	12,964	....	....	....	....	15,204	16,851
Plumas	143	337	89,885	....	....	....	....	90,222	90,365
Sacramento	5,434	11	....	....	....	....	....	11	5,445
San Bernardino	2	533	35,838	1,040	1,301	69,210	....	107,922	107,924
Shasta	1,286	9,674	617,295	....	3,666	....	....	630,635	631,921
Sierra	199	1,778	....	....	....	....	....	1,778	1,977
Siskiyou	1,421	235	18,833	....	....	....	....	19,068	20,489
Trinity	2,340	34	9,788	....	....	....	....	9,822	12,162
Tuolumne	25	9,450	....	....	....	....	....	9,450	9,475
Yuba	7,999	....	....	....	....	....	....	....	7,999
Merced, Riverside, San Diego, and Stanislaus[a]	673	38	46	....	....	....	....	84	757
	27,257	139,492	882,480	165,155	8,378	552,641	28	1,748,174	1,775,431
Total, 1916	29,611	171,600	1,969,783	2,129	7,599	323,339	60,293	2,534,743	2,564,354
Increase or decrease	−2,354	−32,108	−1,087,303	+163,026	+779	+229,302	−60,265	−786,569	−788,923

[a] Yield of single mine in each county combined to avoid disclosing separate output.

From the siliceous ore and old tailings treated in California in 1917 the recovery of silver by amalgamation was 83,142 ounces, valued at $68,508; by cyanidation, 29,937 ounces, valued at $24,668; by chlorination, 283 ounces, valued at $233; and from concentrates sent to smelters, 110,705 ounces, valued at $91,221. From smelting ores silver was recovered amounting to 1,524,109 fine ounces, and valued at $1,255,865. These figures do not include the comparatively small quantity of silver recovered from the gold in placer mining operations.

COPPER.

The mine production of copper in California in 1917 was 48,153,139 pounds, valued at $13,145,807, a decrease of 7,743,979 pounds in quantity and $604,884 in value from the production of 1916. Copper was produced in Amador, Calaveras, Fresno, Imperial, Inyo, Kern, Madera, Mariposa, Placer, Plumas, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Trinity, and Tuolumne counties. The largest production came as usual, from Shasta County, which produced 26,658,879 pounds, valued at $7,277,874, a decrease of 13,100,593 pounds in quantity and of $2,502,956 in value, as compared with 1916. Altogether, in the State, there were 892,579 tons of copper ore treated in 1917, or 41,143 tons less than in 1916. The smelting plant of the Mammoth Copper Co., at Kennett, Shasta County, is the most extensive in the State. It not only handles its own copper ores, but those of some other large copper-producing mines in the county. The Mountain Copper Co., Keswick, Shasta County, ships ores and concentrates from its mines 250 miles by rail to its smelter at Martinez, on San Francisco Bay. The ore of the Engels copper mine and some other mines in Plumas County is concentrated by the flotation process and the concentrates are shipped to smelters in Salt Lake City, Utah. The Calaveras Copper Co., Calaveras County, also concentrates its ores by flotation and ships concentrates to smelters. The Penn Mining Co., Calaveras County, has a 200-ton smelter and ships blister copper. A number of smaller mines in other counties having no reduction works of their own ship their ores to smelters. The copper ores of California in 1917 yielded, in addition to the copper, 32,402.01 fine ounces of gold, valued at $669,809, and 882,480 ounces of silver, valued at $727,164.

LEAD.

The mine production of lead in California in 1917 was 21,868,628 pounds, valued at $1,880,702, as compared with 12,407,493 pounds, valued at $856,117, in 1916. From lead ore was obtained also 123.02 fine ounces of gold, valued at $2,543, and 165,155 fine ounces of silver, valued at $136,088. The total value of the output from the lead-mining industry of the State in 1917 in lead and contained value of gold and silver was $1,129,811, as compared with $860,508, in 1916. This refers to ores classified as lead ores only, and does not include gold and silver obtained from ores classified as silver-lead. The silver-lead ores produced 4,663.44 fine ounces of gold, valued at $96,402, and 552,641 fine ounces of silver, valued at $455,376. The total value of the output from the silver-lead mines of the State in 1917 in lead and contained value of gold, silver, copper, and zinc, was $2,187,900.

ZINC.

The mine production of recoverable zinc in California in 1917 was 10,872,716 pounds, valued at $1,109,017, as compared with 15,256,485 pounds, valued at $2,044,369, in 1916, a decrease for 1917 of 4,383,769 pounds in quantity and of $935,352 in value. The zinc output of the State in 1917 was from the counties of Shasta, Inyo, Siskiyou, San

Bernardino, Amador, and Calaveras, in the order named. Arrangements are being made for a much larger output of zinc in the State, especially in Shasta County.

PRODUCTION BY COUNTIES.

AMADOR COUNTY.

Amador County continued in 1917 to lead all the other counties of California in quantity of ore produced and treated with 804,875 tons, exceeding the next county in rank, Calaveras, by 208,051 tons. Amador ranked third in the production of gold, being displaced in rank by Nevada and Yuba counties in 1917. The gold produced in Amador County in 1917 was valued at $3,664,164, the silver at $21,358, the copper at $650, and the zinc at $787. There were 14 producing deep mines in the county in 1917 and 4 placers. The quantity of ore decreased for the year but there was a small increase in the quantity of gold produced.

Of the total output of ore 23 tons of copper ore were shipped to smelters and 798,952 tons were treated at gold and silver mills. From this milling ore $2,223,613 in gold, and 17,044 ounces of silver, valued at $14,044, were saved as bullion, and 18,456 tons of concentrates were obtained, which yielded $1,422,404 in gold and 8,608 ounces of silver, valued at $7,093. The value of the total gold and silver from milling ore was $3,667,154, or $4.589 a ton. Some 5,900 tons of tailings were also worked, yielding $11,990 in gold and 233 ounces of silver, valued at $192, a total of $12,182. The ore shipped to the smelters yielded no gold, but yielded 10 ounces of silver, valued at $8, in addition to the copper and zinc. The increase of gold from placers was $1,544 in 1917, as compared with 1916. The total increase in values of all metals in the county for the year was $6,107.

There are four important producing deep mines at or near Amador City. The Bunker Hill Consolidated is opened by an incline shaft 2,900 feet deep and drifts on various levels. The reduction works consist of a 40-stamp mill with Deister Overstrom tables, tube mill, and vanners. Five Deister tables and a ball mill were added to the equipment in 1917. The Darrow Leasing Co., which treats tailing from the Bunker Hill mill, moved and rebuilt its plant in 1917. This plant concentrates 400 tons of tailing to approximately 5 tons. The slime tailing is concentrated and the concentrate cyanided by agitation. The Keystone Mines property is opened by an incline shaft 2,960 feet deep and 5,500 feet of drifts, 900 feet of which were cut in 1917. The mine is equipped with a 40-stamp amalgamation and concentration mill, concentrates being shipped to the smelter. The mine of the Original Amador Consolidated Mines Co. is opened by an incline shaft 1,270 feet deep, and 21,627 feet of drifts, raises, and crosscuts. The shaft was sunk 305 feet deeper in 1917 and 1,627 feet of drifts and raises were made. The equipment consists of a 250-ton amalgamating and concentrating mill and an 8-ton cyanide plant for concentrates. Ore is crushed by one ball mill and one pebble mill and the concentrates are cyanided after the pulp has been run over the amalgamating plates. The Treasure Mining Co. mine is opened by a vertical shaft 1,600 feet deep and a winze of 700 feet. The reduction plant consists of a 120-ton ball mill, with regrinding, amalgamation, and concentrating appliances. All these mines at Amador City were operated the entire year. The Fremont Consolidated Mining Co., at Drytown, includes the Gover, North Gover, Loyal Lode, and Fremont mines, all being worked as one property. The property is operated through two incline shafts, 1,550 and 2,800 feet deep, respectively. The reduction equipment consists of a 40-stamp amalgamation and concentration mill in which the ore is crushed wet and concentrated on Frue vanners; the tailings and slimes are treated by the California Slimes Consolidated Co. at the mine. The concentrates are shipped to a smelter. The Ione Coal & Iron Co., at Ione, produced a small quantity of copper and silver.

In and around Jackson and Sutter Creek are the most important of the Mother Lode mines in the State. The Argonaut at Jackson is opened by an incline shaft 4,700 feet deep, with the usual drifts, crosscuts, and raises. During 1917 the old 40-stamp mill was abandoned and a new 60-stamp amalgamating and concentrating mill completed. The concentrates obtained are shipped to a smelter. The Kennedy Mining & Milling Co. has the deepest vertical shaft in the State—4,012 feet, of which 46 feet was sunk in 1917. The property is equipped with a 100-stamp amalgamation and concentration mill and one of the few chlorination plants in the State for treatment of the concentrates. At Sutter Creek the Central Eureka is developed by an incline shaft 3,425 feet deep, and by 5,000 feet of drifting from the 2,540 level down. The reduction equipment consists of a 40-stamp amalgamation and concentration mill, concentrates being shipped to a smelter. The South Eureka is developed by an incline shaft 2,730 feet deep and a vertical shaft of 2,260 feet in depth; there are also two winzes, respectively, 400 and 450 feet, with many drifts and crosscuts. The reduction plant consists of an 80-stamp mill and concentrators at the South Eureka mine and 25 stamps and 11 concentrators at the Oneida mine, a continuation of the South Eureka under the same management.

At Plymouth is the extensive property of the Plymouth Consolidated Gold Mines (Ltd.), owned by English capitalists. The mine is developed by a vertical shaft to the 1,600-foot level and thence by incline (60-foot) in the footwall to the 2,600-foot level. Considerable development was done during 1917. The reduction plant consists of a 30-stamp mill, with Hardinge mills, amalgamating and concentrating in two sizes, regrinding and reamalgamating tailings. The concentrates are sent to a smelting plant. Seventy-five per cent of recovery values is due to free milling operations, and 25 per cent is in the sulphides. A plant for regrinding tailing was added in 1917. In that year the mill extracted $3.72 a ton by amalgamation and $1.56 by concentration, a total of $5.28, equal to 86.37 per cent of the average assay content of $6.12 a ton. The bullion yield was 32,795 ounces of gold and 7,688 ounces of silver. As the tailing assayed higher than before, due to a change in the character of the ore, two Hardinge mills and more copper plates were added. Costs were 46 cents for development, $2 for mining, 38 cents for milling, 24 cents for bullion and concentrate expenses, and 31 cents for maintenance and general expense, a total of $3.39 a ton.

A little placer gold was derived from small mines in this county at Plymouth and Volcano.

BUTTE COUNTY.

In 1917 there were 26 mines reporting production from Butte County. Only 349 tons of ore were reported from deep mines, nearly 1,600 tons less than in 1916. The total gold output of the county in 1917 was $922,271, a decrease of $334,960, as compared with 1916. The total value of gold and silver produced in the county in 1917 was $925,262, a decrease of $335,301. The 11 dredges in the county recovered gold valued at $893,141, which was $317,733 less than 14 dredges produced in 1916. The number of dredges operating was three less than in 1916, several having worked out their available ground and ceased operations. The few drift mines produced $1,980 more gold than 1916; and the surface or sluicing mines $4,879 less gold. The total gold output from placers of all kinds was $917,615, as compared with $1,238,247 in 1916, a decrease of $320,632. The output of deep gold mines in gold was $4,656, a decrease of $14,328 from 1916. Butte County, formerly the leading producer for many years in dredge gold, is now third in rank in this respect, being now exceeded by both Yuba and Sacramento counties.

In 1917 the Oroville district proper yielded from dredging operations $717,782 in gold, which was $252,627 less than in 1916. The following table shows the output of gold from the Oroville dredging field for several years, with the annual increase or decrease:

Mine production of gold of Oroville dredging district, California, 1903–1917, with increase or decrease, by years.

Year.	Production.	Increase or decrease.	Year.	Production.	Increase or decrease.
1903	$1,329,998	....	1911	$1,987,294	−$112,334
1904	1,632,507	+$302,509	1912	2,080,229	+ 92,935
1905	2,261,887	+ 629,380	1913	1,918,050	− 162,179
1906	2,768,782	+ 506,895	1914	1,422,407	− 495,643
1907	2,697,092	− 71,630	1915	1,171,315	− 251,092
1908	3,043,151	+ 346,059	1916	970,409	− 200,906
1909	2,743,232	− 299,919	1917	717,782	− 252,627
1910	2,099,628	− 643,004			

The combined dredges in the county in the Honcut and Butte Creek fields, outside of Oroville district, yielded $175,359 in gold, as compared with $240,465 in 1916.

In 1917 the following dredges were operating in the Oroville field, each with one machine unless otherwise noted: Natomas Co. of California (3), Oroville Dredging Co. (Ltd.), (2), American Gold Dredging Co. (formerly Oro Water, Light & Power Co.), Pacific, and Oroville Union. The last named company has worked out its ground.

The companies producing at Butte Creek and Honcut, outside the Oroville district, are the Pacific, Honcut, and Kentucky Ranch.

Smaller placers were more or less productive at Bangor, Cherokee, Chico, Enterprise, Magalia, Nimshew, Oroville, and Stirling City.

The small producing deep mines of the county are the Springer Consolidated, at De Sablo; Crystal Peak and the Edel, at Enterprise; and California Gold Mines Co., at Oroville.

CALAVERAS COUNTY.

Calaveras, one of the Mother Lode counties, had a production of 596,824 tons of ore in 1917, an increase of 78,644 tons over 1916. The total yield of gold for the county in 1917 was $1,471,442, an increase of $115,322, as compared with 1916; of silver 106,777 ounces, valued at $87,984, a decrease of 20,340 ounces; and of copper, 8,052,978 pounds, an increase of 1,592,685 pounds. The total value of all metals increased by $729,176 in 1917, as compared with 1916. The value of the output of copper in the county in 1917 was $2,198,463, as compared with $1,589,232 in 1916, an increase of $609,231. In 1917 producing mines to the number of 33 reported—12 deep gold mines, five copper mines, five gold dredges, seven drift mines, and four surface placers. From the placers gold recovered by dredges in 1917 amounted to $499,785, an increase over 1916 of $201,305; that from drift mines was $12,378, a decrease of $15,985; and that from surface placers was $5,405, a decrease of $1,860.

The average value per ton of 352,641 tons of milling ore treated at gold and silver mills in the county in 1917 was $2.35 in gold and silver, compared with $2.32 in 1916. This very low average, which has persisted for several years, materially reduces the average value per ton of the five Mother Lode counties when considered as a whole. It is due to the fact that in one large mine development work has been carried on in search of profitable ores, at lower levels, when it was known that the ore mined during the year was of too low a grade to pay for mining and milling. The quantity of ore sold or treated in Calaveras County in 1917 was 596,824 tons, which yielded gold valued at $953,874; 104,339 fine ounces of silver, valued at $85,975; and 8,052,978 pounds of copper, valued at $2,198,463. The placer output was $517,568 in gold, and 2,438 ounces of silver, valued at $2,009. The output of the county in 1917 in gold, silver, copper, lead, and zinc, was $3,758,171.

There were 352,641 tons of ore treated at gold and silver mills, from which was obtained $473,205 in gold in bullion and 4,720 ounces of silver, valued at $3,889. The total saving in bullion was valued at $477,094, or $1.35 a ton. From the 352,641 tons of ore directly milled and 148,690 tons of ore sent to concentrating plants were obtained 26,299 tons of concentrates yielding $349,574 in gold and 4,734 ounces of silver, valued at $3,901, an average in gold and silver of $13.44 a ton. The recovery of copper from ore concentrated was 3,432,904 pounds. There were 40,503 tons of smelting ore sold or treated yielding $65,660 in gold and 94,774 fine ounces of silver, valued at $78,094, or $3.55 a ton in gold and silver; and 4,620,074 pounds of copper, valued at $1,261,280. The total value of the smelting ore was $1,405,316, or $34.70 a ton. In addition there were treated 54,990 tons of old tailings yielding $65,435 in gold and 111 ounces of silver, valued at $91, a total of $65,526, or an average of $1.19 a ton.

The Angels Quartz Mining Co., at Angels, again became productive in 1917, after some time spent in opening old ground. The Royal Gold Mines, after some years of idleness, were reopened and became productive. The Utica Mining Co. is the largest producing property at Angels, ore coming from both the Utica and the Gold Cliff claims. This property is opened by three shafts, one 1,400 feet, one 2,900 feet, and one 2,700 feet deep. There are two mills on the property, one of 60 and one of 40 stamps, using amalgamation and concentration; the concentrates are shipped to a smelter. The most productive mine in the county is that of the Penn Mining Co., at Campo Seco, a copper mine yielding also largely in gold and silver. This mine is opened by an incline shaft 2,900 feet deep. The equipment consists of a 200-ton smelter, where the crude ore is smelted, and whence blister copper is shipped to the American Metal Co., New York. The Tullock is a small gold mine at Carson Hill. The extensive property of the Calaveras Copper Co. is at Copperopolis. It is opened by one incline shaft 740 feet deep, one incline shaft 896 feet deep, and one vertical shaft 140 feet deep. Development work in 1917 consisted of 470 feet of shaft sinking, 2,430 feet of drifts, and 490 feet of adits. The reduction plant is a concentration mill consisting of one Allis-Chalmers and two Hardinge ball mills and other equipment, which has a capacity of 600 tons daily. The crude ore is treated by the oil flotation process and the concentrates are shipped to a smelter at Tacoma, Wash. During 1917 the discovery shaft was extended to the tenth level and a new shaft was started on the North Keystone Claim, which was sunk 140 feet and drifts started. In addition to company work considerable ore was mined by lessees at this mine. The Plymouth Rock, at Jenny Lind, is opened by two small shafts and about 1,000 feet of drifts. Only a few carloads of ore were shipped during the year, although continuous development has been going on. The Melones Mining Co. operates one of the larger of the Mother Lode mines, at Melones. The property is opened by an adit 5,000 feet long and an incline winze 2,000 feet deep. About 2,300 feet of development work was accomplished in 1917. The reduction plant consists of a 100-stamp amalgamating, concentrating, and cyaniding mill. The process consists of amalgamation, concentrating on Wilfley tables, classification sands to leaching tanks, slimes to Dorr dewaterer, Devereux agitators, and Oliver filter, concentrates being ground in tube mills and cyanided in Devereux agitators. The Carson Hill gold mines, also at Melones, are opened by an adit 2,160 feet long. During 1917 the company did 200 feet of sinking, 1,200 feet of drifting, 250 feet of crosscutting, and 1,000 feet of raising. There are two amalgamating and concentrating mills on the property, one of 3 and one of 10 stamps, which were only in operation a part of the year. The Copper Crescent is a small copper mine producing near Milton. The Napoleon copper mine, also near Milton, is opened by a 250-foot shaft. There is a 50-ton flotation plant on the property and the concentrates are shipped to the smelter at Tacoma, Wash. The Quail Hill Mining Co. is working a copper mine in the same vicinity and has a 270-foot vertical shaft. Shaft sinking and drifting were done in 1917. The company has no plant in operation, but shipped crude ores to the Mammoth Copper Co. and to the Tacoma Smelting Co. The Pacific Gold Mining & Milling Co. (formerly the Mokelumne Mines Co.) has its property at Mokelumne Hill. The mine is opened by an adit 2,000 feet long and a vertical shaft 190 feet deep and 1,500 feet of lateral work from the shaft. In 1917 2,359 feet of development work was done. There is an amalgamation and concentration plant of 100 tons daily capacity. The ore is crushed in a ball mill to 20 mesh, and amalgamation is followed by table concentration. Concentrates are shipped to the smelter on San Francisco Bay. The metallurgical plant was idle for two months of the year while the shaft was being sunk. The Comet and Josephine are small gold mines at Railroad Flat; and the Deer Foot and Newman are small gold mines at West Point.

The most important placers in the county are those operated on Mokelumne River by the American Gold Dredging Co., the successor of the old Oro Water, Light & Power Co. The work is being done on low bench gravel. Three dredges are operated by this company in the vicinity of Camanche. As a matter of fact, however, all these dredges are not in Calaveras County, but their combined output is reported as from Camanche and is so considered in this report. No. 1 dredge is on the river 2 miles from Camanche, in Calaveras County; No. 2 is 7 miles from Camanche in San Joaquin County; and No. 3 is 4 miles from Camanche, in Amador County. The Butte Dredge Co. operated a dredge on stream gravel in Calaveras River near Jenny Lind for 322 days in 1917 and then shut down finally. The Ivy L. Borden Co. began operating a dredge on stream and bench gravel near Jenny Lind in June, 1917. Small placer mines produced more or less gold at Angels, Camanche, Jenny Lind, Mountain Ranch, Railroad Flat, San Andreas, and Sheep Ranch. The Stockton Ridge Consolidated Mining Co. operated a drift mine for some months at Mokelumne Hill, but expenses due to war condition caused a permanent shut down there, and at other mines in the vicinity. The Oneta and Steward placers both made small outputs at San Andreas, as did the Vandalia, at Sheep Ranch.

DEL NORTE AND HUMBOLDT COUNTIES.

In Del Norte County the Salt Lake & California Copper Co. made a small output of copper at Smith River. Most of the productive placers are small ones at or near Crescent City. These are the Craigs Creek, French Hill, Myrtle Creek, and a few smaller sluicing claims.

In Humboldt County the only deep mine reporting was the Prospect Hill Co., at Orleans, which has a 2-stamp mill. At Orleans are the Croton Bar hydraulic, Jungle sluicing mine, Reynolds Creek hydraulic, Rocky Bar hydraulic, and sundry smaller placers. At Weitchpec the Klamath River Mining Co. is sluicing in ancient river beds and the Weitchpec Bar mine is hydraulicking. There are some smaller placers at this place also.

ELDORADO COUNTY.

Eldorado is one of the five Mother Lode counties of California, but its mining activities are by no means so great as formerly and no extensive deep mining operations are now being conducted in the county. The placer mines also are less productive and very much less in number than in the past. The principal reason for the very marked falling off in output of gold is the fact that the Pacific Gold Dredging Co., formerly working on the Eldorado side of American River, was in 1917 working on the Placer County side, so that its output is properly credited to Placer County instead of to Eldorado, as formerly. There is not a single deep mine of any productive prominence now at work in the county, whereas there were formerly several.

The output of gold of the county in 1917 was only $24,758 as compared with $361,821 in 1916, and that of silver was valued at $85, as compared with $1,496 in 1916. There was a decrease of 9,988 tons of ore treated and a decrease of $337,063 in gold and of 2,170 ounces of silver. The decrease in total value of metallic output of the county in 1917, as compared with 1916, was $338,474, which is the greatest percentage of loss in any county in the State. The ore treated at gold and silver mills, amounting to 2,506 tons, yielded bullion valued at $3,083, or an average per ton of $1.23 in gold and silver, as compared with an average of $4.89 per ton in 1916. There were 66 tons of concentrates derived from the milling ore, which yielded $2,545, or $38.57 a ton in gold and silver, as compared with $46.94 a ton in 1916. The milling ore yielded in bullion and concentrates a total value of gold and silver of $5,628, or $2.25 a ton, as compared with $74,370, or $6.09 a ton in 1916.

The placer mines of the county yielded $19,158 in gold, and 69 ounces of silver, valued at $57, as compared with $284,930 in gold and 1,588 ounces of silver, valued at $1,045, in 1916. There were 14 mines (11 placer and 3 deep mines) of the county which reported production, as compared with 25 mines in 1916.

The Marigold & Frog Pond Consolidated mines, at Garden Valley, crushed a few hundred tons in its 2-stamp mill in 1917. There was also a small output from the Morning Star and Lucky Boy, at Georgetown. The mine of the Guildford Gold Mining Co., at Placerville, was the only deep producing mine of any note in the county, and this was operated for only three months of the year.

Of the placers the Blue Rock in the Georgia Slide district, near Georgetown, carried on drifting operations for seven months of the year. A few small placers were producers in the same region. A small output was made from the Grizzly Flat drift gravel mine, at Grizzly Flat, and from the Jinkerson drift mine, at Indian Diggings. A few small placers were worked at Omo Ranch. At Placerville the placers operated productively were the Live Oak, and the Rising Hope. The Deadman Flat ground sluicing placer, and the Friedman. made a small output at Rescue, and there were a few producing placers at Shingle. The Fort Jim drift mine, at Smith Flat, made a nominal yield.

INYO COUNTY.

In 1917 there were 37 producing deep mines in Inyo County. Of these mines 4 were gold, 4 copper, 16 silver-lead, 11 lead, and 2 zinc. The total value of the metallic output for the year was $2,956,669, or $971,056 more than in 1916. The value of the gold was $125,394, or $6,328 less than in 1916. The silver yield amounted to 648,785 ounces, valued at $534,599, making this county the first in rank of output of silver in the State, displacing for the first time in many years Shasta as the leading silver county. The increase in the yield of silver in Inyo County in 1917, as compared with 1916, was 295,531 fine ounces in quantity and $302,158 in value. The output of copper in 1917 was 737,582 pounds, valued at $201,360, an increase in quantity of 531,436 pounds and in value of $150,648. The output of lead in the county was 19,671,732 pounds, valued at $1,691,769, as compared with 11,497,015 pounds, valued at $793,294, an increase in quantity of 8,174,717 pounds and in value of $898,475. The production of zinc in 1917 was 3,956,343 pounds, valued at $403,547, a decrease in quantity of 1,845,478 pounds and in value of $373,897, as compared with 1916.

There were sold or treated in 1917 in Inyo County 84,354 tons of ore, of which 2,169 tons were siliceous ore, 382 tons copper ore, 27,714 tons lead ore, 53,954 tons silver-lead ore, and 135 tons zinc ore. The deep mines in 1917 yielded gold valued at $125,394 and 648,785 ounces of silver, valued at $534,599. Of the gold 1,315.46 fine ounces, valued at $27,193, was obtained from siliceous ore, $331 from copper ore, $2,543 from lead ore, and $95,327 from silver-lead ore. The production of silver from siliceous ore was 550 fine ounces, valued at $453; from copper ores 661 fine ounces, valued at $545; from lead ores 164,115 fine ounces, valued at $135,231; from silver-lead ores, 483,431 fine ounces, valued at $398,347; and from zinc ores 28 fine ounces, valued at $23. The siliceous ore, therefore, yielded $27,646 in gold and silver; the copper ores $876; the lead ores $137,774; the silver-lead ores $493,674; and the zinc ores $23; a total of $659,993 in gold and silver.

At Big Pine the Base Metals Mining Co. is working a lead mine. At the same place ore from the Fish Springs Hill mine was worked in an arrastre and also shipped to smelters at Salt Lake City, Utah. The Roberts mines are producing silver-lead ore which is shipped to Nevada. On this property there are three shafts each about 125 feet deep. The Montezuma is a silver-lead mine, with ores of low grade. At Darwin lead ores were produced by the Argus Sterling Mining Co. The Christmas Gift, a silver-lead property, is opened by a 255-foot incline shaft and a 150-foot winze. The ores are shipped to smelters at Salt Lake City. The Columbia is a small producer of copper ores, and the Custer Mining Co. produces silver-lead ores. The Coso Mining Co. proluced a small quantity of copper. The silver-lead mines of the Darwin Lead & Silver Mines Development Corporation yield gold, silver, copper, and lead. The Inyo County Mining & Development Co. mines lead ores only, and the same is true of the Rip Van Winkle. Zinc ores mined by the Utacal Exploration Co. were shipped to Salt Lake City. Several small mines at Darwin shipped more or less silver-lead, lead, and copper ores. At Independence the Black Eagle is opened by a 310-foot vertical shaft, and has a 2-stamp mill, and the Golden Star produced some copper ore. The most productive property in the county is that of the Cerro Gordo Mines Co., at Keeler, mainly worked for lead, but producing also largely in zinc and silver, with some gold. The Estelle Mining Co. operates the Consolidated Morning Star group of 41 claims at Keeler. The property is opend by an adit 7,300 feet long, which was extended 190 feet in 1917. Nearly 500 feet of drifts, raises, and winzes were also cut. The working force at the mine was somewhat disorganized by enlistment of men in the United States service. The company owns no reduction plant, but ships its silver-lead ore to a smelter. The Santa Rosa Lead & Silver Mining Co. shipped considerable silver-lead ore containing some copper to the smelters. Other shippers at Keeler were the Spear (lead), San

Lucas (copper), Royal Group (silver-lead), and Ygnacio (silver-lead). Ore from the Nellie H., at Lone Pine, is crushed in a horsepower arrastre, but some small shipments of crude ore were made to a smelter. The Reward, at Owenyo, is opened by an incline shaft 300 feet deep, an adit of 800 feet, and 5,000 feet of drifts. During 1917, 723 feet of drifting, 632 feet of crosscutting, and 386 feet of raising was done. The reduction works consist of a 20-stamp concentration-flotation mill, and 10 stamps, and concentrating tables. The process consists of stamping, classifying, tabling, and regrinding in ball mills. Sometimes higher grade ore is shipped to the Selby smelter. The ores carry gold, silver, lead, and copper. Oil flotation gave poor results and tables were added to remove the oxides and carbonates of lead, copper, and iron so as to leave as little as possible in the pulp treated by flotation. The Madison is a small zinc mine at Shoshone. Some gold was shipped from the Skidoo Mines Co., but the property was later closed down. Lead ores were shipped from Tecopa by both the Ore Gulch and Speculator mines, but the principal mine is that of the Tecopa Consolidated Mining Co., which produces lead, silver, and gold. The concentrating plant was burned in June, and in December work was started on a new 100-ton concentrating mill. Considerable ore was shipped to smelters in Utah, The mines owned by the company are the Gunsite, Noonday, Giant, and Columbia. The Slate Range Minerals Co. operated the Copper Queen mine, the nearest post office to which is Trona. The ores carry lead, silver, copper, and gold. The crude ore is sorted and shipped to a smelter at Salt Lake City. The Ophir mine, near Trona, produced silver-lead ores, which were shipped for reduction to smelters at Salt Lake City. The ores of the Carbonate Lead Mines Co., at Zabriskie, carry principally lead and silver, but also contain some copper and gold. From this same vicinity the Blue Mountain and Ibex & Arcturus mines shipped lead ores in 1917, and the Fraser shipped a small quantity of copper ores.

KERN COUNTY.

Nineteen deep mines reported production from Kern County in 1917 and only one placer. The total value of the metallic output of the county decreased from $760,707 in 1916 to $616,645 in 1917. The total production of gold was $537,852 in 1917, as compared with $747,042 in 1916. The silver output in 1917 was 9,482 ounces, valued at $7,813, as compared with 13,290 ounces, valued at $8,745, in 1916. Copper to the amount of 260,000 pounds, valued at $70,980, was produced in 1917, as compared with 20,000 pounds, valued at $4,920, in 1916.

There were treated or sold 125,649 tons of ore in 1917, of which 123,140 tons were siliceous ore, 2,417 tons copper ore, and 92 tons of silver ore. A total of 123,140 tons were sent to gold and silver mills, and 2,509 tons to the smelters. The yield in bullion from the ore treated at gold and silver mills was $532,880 in gold and 5,949 ounces of silver, a total bullion value of $537,782 in gold and silver, and an average value per ton of $4.36. No concentrates were derived from this ore. From the 2,509 tons of ore sent to smelters there was obtained $4,795 in gold and silver, or an average of $1.91 a ton. In addition, the 2,509 tons of ore sent to the smelters yielded 260,000 pounds of copper. The total yield of the county in gold, silver, and copper from the deep mines was $615,642, an average of $4.90 a ton. The single placer made a nominal production of gold.

The Glen Olive mine at Bodfish, worked under lease, produced a small quantity of gold, as did the Early Sunrise mine at Isabella. The Mammoth Mountain mining property at the same place, is opened by a 4,000-foot adit and a vertical shaft of 210 feet. Prospecting for an ore body was carried on much of the time. The mine is equipped with a 10-stamp mill, but only a small output was made. The Keys Mining & Milling Co., which has a 5-stamp mill, is opened by an adit of 900 feet, a vertical shaft of 325 feet, and some 1,200 feet of drifts. The Shipsey Mining Co., operating the King Solomon group of mines at Johannesburg, has on its property three incline shafts from 100 to 450 feet deep, and it sunk a 100-foot shaft in 1917. There is a small mill on this property. The Zenda Mining & Milling Co. worked a mine producing silver ore only. The Trio Mining Co., Mojave, operated to July 10, 1917, and then closed. On this mine is a 10-foot Layne mill with Senn concentrators. The Black Hawk group, at Randsburg, was worked by the Yellow Aster Mining Co. under option after May, 1917. The Butte Lode Mining Co., at Randsburg, made some output of gold. The Consolidated Mines Co., after making a small output, discontinued work in the mine. The Pay Day, Santa Ana, and Windy, at Randsburg, each made a small output. Several lessees worked on the Royal Bohee. The most important of the gold producers at Randsburg, as for many years, was the Yellow Aster group. Though worked last year mostly from the "glory hole," this property has about 8 miles of tunnels, shafts, and drifts. The mine was operated for about nine months during 1917 and then closed down to hasten the building of the crushing and screening plants. There is a 100-stamp mill on the property, which uses the amalgamation process only with no concentrating. The Tropico Mill & Mining Co., at Rosamond, added 100 feet to its 600-foot incline shaft and straightened the shaft. Mill work was suspended during this time. There is a 10-stamp mill and a 35-ton cyanide plant on the property. The Blue Mountain Mining Co., at White River, has a 5-stamp amalgamating and concentrating mill and deepened its shaft 80 feet and ran 800 feet of drifts in 1917. The Weringer Mines Co., at Woody, produced considerable copper ore.

MADERA COUNTY.

Madera County in 1917 produced a total of $135,128 in value of metals, as compared with $53,661 in 1916, an increase of $81,467. The 6,230 tons of ore treated or sold and the few small placers yielded $18,914 in gold; 593 fine ounces of silver, valued at $489; and 423,901 pounds of copper, valued at $115,725, a total of $135,128. Three deep gold mines and 4 copper mines reported production in 1917, and 1 placer mine had a nominal output.

The Kroromick (formerly called the Texas Flat), at Coarsegold, is developed by an incline shaft 900 feet deep, with levels each 125 feet. The mine is equipped with a 20-stamp amalgamation and concentration plant, but only 10 stamps were used during 1917. At the Gambetta mine, Grub Gulch, most of the time in 1917 was spent in installing a transmission line and new equipment. The mine is developed through an 860-foot incline shaft, with some 2,000 feet of drifts. There is a 100-ton ball mill and concentrating plant on the property. The Mud Springs & Keating mine, at O'Neals, made a nominal output in gold. The Buchanan Copper Co. mine, at Raymond, was worked by lessees and the ore was shipped to the Mammoth Copper Co's. smelter at Kennett, Shasta County. Other copper-ore producers near Raymond were the Bussolini, Copper Queen, and Madera County mines. A few small placers at Coarsegold yielded some gold.

MARIPOSA COUNTY.

Mariposa, which is one of the mother lode counties of California, showed a decrease of $119,289 in the value of its total metallic ouput in 1917, as compared with 1916. The total value in 1917 was $326,482; in 1916 it was $445,771. Of the 13 mines reporting production in 1917, 11 were deep mines. The output of ore decreased by 27,125 tons. The output of gold was $313,296 in 1917, as compared with $401,718 in 1916, a decrease of $88,422. The silver output decreased 164 ounces and the copper decreased 131,681 pounds.

The deep mines of the county produced 41,876 tons of ore, of which 328 tons went to the smelters. The 41,548 tons of ore which went to the gold and silver mills yielded $268,471 in gold as bullion, and 2,387 ounces of silver, valued at $1,967, the total gold and silver value of the bullion being $270,438, or an average value of $6.51 a ton. From this ore were also derived 711 tons of concentrates, which yielded $41,008 in gold and 982 ounces of silver, valued at $809, a total of $41,817. The yield of the concentrates is thus shown to have been $58.81 in gold and silver a ton. The 328 tons of ore shipped to smelters yielded $2,481 in gold, 535 ounces of silver, valued at $441, and 36,502 pounds of copper, valued at $9,965, an average value per ton for gold, silver, and copper of $39.29. The siliceous ore yielded on the plates and from the concentrates a total value of $312,255 in gold and silver, an average value per ton of $7.51.

A small amount of gold came from the Red Banks property, at Bagby, and a few small properties in that neighborhood. The White Gulch Mining Co. (Virginia mine), at Coulterville, made a considerable output. This property is developed by an incline shaft 700 feet deep, of which 284 feet was sunk in 1917. There are also about 4,800 feet of drifts and crosscuts. The reduction works consist of a 10-stamp amalgamation and concentration mill. The ore is crushed in a Blake crusher and stamped through a 40-mesh screen and then passed over check, lip, and sluice plates, and a 6-foot Union concentrator. The Original, at El Portal, is opened by a 680-foot vertical shaft, a 551-foot adit, and 4,500 feet of drifts. The shaft is in the adit tunnel level and the collar is 185 feet below the surface. Some 1,800 feet of work was done in 1917. On this property is a 10-stamp amalgamating and concentrating mill. The mine was worked throughout the year and the mill was run about eight months. At the Ruth Pierce mine, Hornitos, new electric motors were put in both mine and mill during 1917. There is at the mine a 10-stamp mill with Frue concentrators. Several small mines near Hornitos were worked productively during 1917. The Early, Revel, and Louise mines at or near Jerseydale, made small outputs of gold.

The Johnny Green mine, at Lewis, produced some copper ore which was shipped to Tacoma, Wash., and Kennett, Cal. The Mariposa Commercial & Mining Co., at Mount Bullion, did no mining on its own account, but milled some gold ore mined by lessees on its property. The Mountain King mine, at Mountain King, is developed by an adit of 1,600 feet, a vertical shaft of 450 feet, and 6,000 feet of drifts. It is equipped with a 30-stamp amalgamation and concentration mill. The Green Mountain mines, at Raymond, made a small output of copper. The Somersville mine, at Whitlock, made a small yield of placer gold, as did a few mines at Jerseydale.

MONO COUNTY.

The total value of the metal output in Mono County decreased from $240,690 in 1916, to $214,702 in 1917, or $25,988. The decrease in gold was $28,044. The output of silver increased from 5,480 ounces, valued at $3,606, in 1916 to 6,871 ounces, valued at $5,662, in 1917, or 1,391 ounces in quantity and $2,056 in value.

There were 18,090 tons of crude ore treated at the gold and silver mills, which yielded $203,416 in gold, and 5,186 fine ounces of silver, valued at $4,273, a total value of $207,689, or an average value of $11.48 a ton in gold and silver. The average value of this ore per ton in 1916 was $21.18, which accounts for the reduction in total value of output of the county in 1917. No concentrates were reported. There were 686 tons of old tailings treated, which yielded $7,013 in gold and silver, or an average of $10.22 a ton. The total value for the 18,776 tons of ore and tailings was, therefore, $214,702 in gold and silver, or an average value of $11.43 a ton, as compared with the average value in 1916 of $20.90 per ton. The old Standard mine at Bodie, now owned by an individual instead of a company, is still a producer, although by no means so large a one as formerly. There is on this mine a 20-stamp amalgamating mill and 100-ton cyaniding plant. The Serita Mining Co., at Masonic, made a considerable output of gold during 1917.

NEVADA COUNTY.

Nevada County outranked all the other counties of California in the production of gold in 1917, as also in 1916. It is also one of the three counties which exceeded a three-million dollar output of gold, its total yield of gold having been $3,682,947, as compared with Yuba County with $3,677,673, and with Amador County with $3,664,164. The production of gold from deep mines increased $30,599; that from placers decreased $17,530. The average value per ton of ore treated in gold and silver mills in this county was nearly $10 as compared with $8.95 in 1916.

The quantity of ore and old tailings treated in the county in 1917 was 480,869 short tons. There were 22 producing mines that reported, of which 18 were deep or quartz gold mines and 4 placers. The hydraulic mines produced in gold $7,019, and the drift mines $9,351, a total value of $16,370 from the placers. The deep mines produced gold valued at $3,666,577 and silver valued at $52,293, a total value of $3,718,870.

There were 337,596 tons of siliceous ore treated at gold and silver mills. The value of the gold in the mill bullion was $3,292,110, an average value of $9.75 a ton, and the silver output from the same source was 34,432 fine ounces, valued at $28,372, or $0.08 a ton. The total value of the gold and silver recovered in the mill bullion was $3,320,482, an average value of $9.83 a ton. From the milling ore there were obtained 1,096 tons of concentrates which carried $54,175 in gold and 2,238 ounces of silver, valued at $1,844. The total value of the concentrates was $56,019 in gold and silver, or an avereage value of $51.11 a ton. From the 337,596 tons of milling ore there was recovered from both bullion and concentrates $3,346,285 in gold and 36,670 ounces of silver, valued at $30,216. The total value of the gold and silver recovered from bullion and concentrates was $3,376,501, the average value per ton being $10 in gold and silver. There were 143,273 tons of tailings treated, yielding $320,292 in gold and 26,792 ounces of silver, valued at $22,077. Doubtless a large proportion of this quantity was not " old " tailings, but those treated at once after the ordinary milling process was completed and before being allowed to pass away into the streams or impounding dams. They were simply reported as "tailings" with the resultant yield.

At the Republic Mining & Milling Co., Graniteville, no development work was done on account of the high cost of powder and other supplies. Only a small quantity of ore was milled. There is a 10-stamp mill on the property and a 6-foot Huntington mill was added during the year. Very little was done at the Ben Harrison mine, Grass Valley, but some development work was carried on. At this mine there is a 10-stamp amalgamation and concentration mill. On the mine of the Brunswick Consolidated Gold Mining Co. there is one vertical shaft of 1,350-foot depth and an incline shaft of 1,250 feet with several miles of drifts. The property is equipped with two 20-stamp amalgamation and concentration mills, the concentrates being sent to a smelter. At the mine of the Central Consolidated Mining Co. a small crew carried on work until July when the mine was put in the hands of lessees. This mine is opened by an adit 1,000 feet in length and an incline shaft of 500 feet, with some 9,000 feet of drifts. There is on the property a 20-stamp amalgamation and concentration mill. The Empire Mines Co., one of the most productive of the deep-mine operators of the State, worked the Empire mine and Pennsylvania Shaft as one property. There are two incline shafts, one 5,000 feet deep and one 2,600 feet deep. The reduction equipment consists of one 60-stamp mill and cyanide plant and one 20-stamp mill and cyanide plant. The mine was worked continuously through the year. The Golden Center of Grass Valley Mining Co. sunk 120 feet of shaft and did 1,674 feet of drifting during the year, but struck a bad flow of water in July which partly flooded the shaft. The company is working the old Dromedary location, which was worked from the surface as far back as 1855. The property is equipped with a 20-stamp amalgamation and concentration mill. The North Star Mines is one of the most important of the deep gold producers of California, and its mill is provided with an extensive cyanide plant. During the year the Central mill was equipped with sixty 1,500-pound stamps and the Central cyanide plant was enlarged to perform the work formerly done by two 40-stamp mills and separate cyanide plants. After working until May the old North Star mill was dismantled. The yield per ton of ore crushed in 1917 was

$1.01 more than in 1916, but the cost per ton of operation was $1.15 more than in 1916, principally due to increased cost of supplies. The total cost per ton of operation and development together in 1917 was $7.19, as compared with $6.26 in 1916. Of the total production of $1,148,684 in 1917, 82.06 per cent was obtained in the mills by amalgamation, and 17.94 per cent was recovered by cyanidation. It is estimated that the value lost in the tailings was about 40 cents per ton of ore crushed. According to the published annual report the profit for the year was $426,260 and dividends amounting to $250,000, or 10 per cent on the capital stock, were paid during the year, making $5,337,040 to date. No development work was done below the 4,400-foot level. This company owns the Champion group of mines at Nevada City, which was also operated throughout the year but without very much encouragement. The production was $188,329, which resulted in a deficit. During the year 41,650 tons of rock were crushed, yielding $4.52 per ton. The rock came from the 2,700-foot level of the Champion and Providence veins. Some fair ore has been developed above the 2,700-foot level in the Providence which shows signs of improvement in depth. The Union Hill mines made a small output during the year.

At Nevada City are several producers, among them the Montana Relief Hill, and Bear Valley Mining Co. The Oustamah has diverted its mill to the crushing and concentration of chrome ores. The Black Bear Mining Co., at Rough and Ready, with a 10-stamp mill, made a small output. The Columbia Consolidated Mining Co., at Washington, got its property equipped and opened in 1917, and made a small production. The Gaston Gold Mining Co. has a 10-stamp mill doing amalgamation only, no concentrates having been produced. Several of the mills at Washington are now at work concentrating chrome ores instead of gold ores. Sundry small placers were operated productively at French Corral and North Bloomfield. Lessees operated the You Bet Mining Co.'s property when water was available. This property is 7 miles east of Colfax. The Omega hydraulic mine at the head of Scotchmans Creek, 4 miles from Washington, was worked for a short time only.

PLACER COUNTY.

The Placer County production of gold and silver in 1917 was valued at $552,571, as compared with $453,328 in 1916, an increase of $99,243, entirely due to the increased output of the placers, mainly dredges. The total yield of gold was $538,686 and that of silver was 16,851 fine ounces, valued at $13,885.

The deep mines produced from 16,654 tons of ore gold valued at $120,285; 15,204 fine ounces of silver, valued at $12,528; and 633,747 pounds of copper, valued at $173,013. The placer mine yield was $418,401 in gold and 1,647 ounces of silver, valued at $1,357, a total of $419,758. The yield from placer mines was $171,905 more in 1917 than in 1916. The decrease in gold from deep mines was $61,037. The total metallic output of the county in 1917 was valued at $725,584, an increase of $97,990, as compared with 1916. There were 21 producing placers in the county in 1917, and 5 productive deep mines, a total of 26. Placer County continues to be the leading drift mining county of the State.

Of the deep mines the Oro Fino Mining Co., at Auburn, operated full time until June, when a shortage of labor compelled a reduction of operations for the remainder of the year. During some months they employed two shifts a day and in others only one shift. The mine is opened by a 600-foot incline shaft, of which 200 feet were sunk during 1917; 2,434 feet of drifting was also done. The reduction plant consists of a 10-stamp amalgamation and concentration mill, the concentrates being shipped to a smelter on San Francisco Bay. Very little productive work was done on the Reno Consolidated mine, at Forest Hill. The most productive deep mine in the county was the Dairy Farm copper mine, owned by the Van Trent Mining Co., near Lincoln, which was operated for nine months and then closed down and abandoned. There was no reduction plant at the mine, the copper ores having been shipped to smelters. The Valley View copper mine, near Lincoln, carried on development and experimental work most of the year, but shipped some concentrates to a smelter. During the year a 30-ton ball mill and concentrators were put in. The Pioneer Gold Mining Co., at Towle, operated productively during the year.

On Quartz Flat, near Auburn, the Lincoln gold dredge worked bench gravel from January to July 10, 1917. The Pacific Gold Dredge Co. dredged stream gravel on Middle Fork of American River, near Auburn, for eight months, half of the time in virgin gravel. A few small surface placers in the vicinity of Auburn were producers. The Haub drift mine worked an ancient river channel 5 miles from Blue Canyon for 10 months of the year; and the Lost Camp, a mile and a half from Blue Canyon, worked quartz gravel by sluicing, and obtained a good many nuggets during the work. The Eldorado and Placer Counties Gold Mining & Power Co. dredged stream gravel at the Poverty Bar mine on Middle Fork of American River, three-quarters of a mile from Butcher Ranch. The work was continued from January 1 to August 20, on which date the dredge sunk and operations were not renewed until December 8. A nominal output of gold was obtained from sluicing at the old Miner claim, at Colfax. The Union placer, at Dutch Flat, and a number of small claims produced some gold. Small amounts of gold were produced by the Golden Channel, at Emigrant Gap, and by the Dardanelles at Forest Hill, where some smaller mines also produced. The largest producing drift mine in the county was the Excelsior, or Reamer Mining Co., at Forest Hill. At Iowa Hill, the Gleason Consolidated and other drift mines made considerable production. At Last Chance, the following drift mines were producers: Red Star, Dixie Queen, Home Ticket (Frankmont), Glen, and Pacific Slab. There was some output from Chinese miners at Michigan Bluff.

PLUMAS COUNTY.

The total yield in metals from Plumas County in 1917 was $799,196 greater in value than in 1916, and in 1916 it was $713,725 greater than in 1915, which increase really shows the marked growth of the copper mining industry in the county, as the output of gold has decreased slightly. The quantity of ore treated in the county in 1917 was 8,995 tons larger than in 1916.

The production of gold from deep mines was $78,739; the silver amounted to 90,222 fine ounces, valued at $74,343, and the copper to

7,471,092 pounds, valued at $2,039,608. The increase in the copper was 2,321,088 pounds in quantity and $772,707 in value. There were 189,973 tons of ore treated, of which 13,879 tons was siliceous ore and 176,094 tons copper ore. The copper ores of the county yielded a concentrate high in copper but low in gold and silver. The ore sent to gold and silver mills produced $51,326 in gold in the bullion, and 335 ounces of silver, valued at $276, a total of $51,602. From the ore treated at concentrating plants there were derived 12,409 tons of concentrates yielding $25,902 in gold and 80,848 ounces of silver, valued at $66,619, or an average per ton of $7.45 in gold and silver. The 3,797 tons of ore sent to smelters yielded $1,511 in gold and 9,039 ounces of silver, valued at $7,448, or a total of $8,959. The 7,471,092 pounds of copper was derived partly from the concentrates and partly from crude ore shipped to smelters. Of the producing mines 20 were placers and 12 deep mines. Of the placers 7 were hydraulic mines, 7 were drift, and 6 were surface placers. The hydraulic mines produced $22,361 in gold and silver, the drift mines $23,028, and the surface placers $7,945, a total of $53,334. There was an increase of $4,260 in the production of gold from all classes of placer mines in 1917.

Of the deep mines the Last Chance copper property was the only producer at Chilcoot. The Five Bears, at Genesee, produced copper ore carrying some silver but no gold. The Jamison Mining Co., at Johnsville, a gold mine, was compelled to close down early in November until provision was made for the storage of mill tailings, which is one of the burdens imposed by the Government on gold mining in California. This property is opened by a shaft 165 feet deep, an 1,800-foot drain tunnel, and 5,532 feet of drifts, raises, and crosscuts. It is equipped with a 20-stamp amalgamation mill. The Plumas-Eureka Corporation, at Johnsville, is opened through an adit of 7,300 feet in length, though there was a small yield, only prospecting was under way in 1917. The mine has a 20-stamp amalgamation mill. The Walker Mining Co. (copper), at Portola, installed in 1917 a new Marcy mill, a Dorr thickener, an Ingersoll-Rand 9-mill compressor, new bunk houses and dwellings, and a power line 14 miles long. A 100-ton flotation plant was also installed. The concentrates are shipped to Utah for treatment. Among the smaller producers were the Crown Point group, at Quincy; Empire Mines Co., at Seneca; Seneca Consolidated Gold Mining Co., at Seneca; Beetle (copper), Sierra Range Copper Co., and Ruby Copper, at Taylorsville. The largest producing deep mine in the county was the Engels Copper Mining Co., at Taylorsville, which is opened principally by adits having a total length of 11,000 feet. Two 3-compartment shafts were being sunk in 1917. The reduction works consist of a 500-ton concentrating plant at the copper mine and a 600-ton unit of a new mill at Superior, completed at the last of the year. Ball and tube mills are used for crushing the ore and the oil flotation process for concentration; concentrates are shipped to Garfield, Utah. The Missouri Bar, Oak Flat, and a few other small placers were producers at Belden. At Crescent Mills the placer producers were the Golden Key and Great Divide. There were also some small placers producing at Greenville; and at Johnsville the Continental mine and the

Standard Mining Co. reported some output. The Consolidated Alturas Placer Mining Co. made a considerable output from river bed gravels and old tailings on Slate Creek, near Laporte; and the Menifee, Plumas Grass Valley, and a few smaller properties were producers in the same region. The New York hydraulic, at Meadow Valley, and the Golden Eagle placer, at Quincy, were producers in a small way. The Seneca Development Co. recovered considerable gold from its drift mine on North Fork of Feather River, near Seneca; and the Yankee Bar, or Dean mine, in the same section made a small output. The Spring Garden Mining Co., about 3 miles from Spring Garden, obtained its gold by the use of a "shooter" with an automatic gate.

SACRAMENTO COUNTY.

Sacramento was fourth in rank among California gold-producing counties, and its total output of gold in 1917 was $1,919,581, or $85,726 more than in 1916. The total yield of gold and silver was $1,924,068, or $86,635 more than in 1916. Virtually the entire output of the county was produced by gold-dredging operations in the vicinity of Folsom. Twelve dredges were at work in 1917, of which 11 were owned by the Natomas Co. of California, and the remaining one by the Indiana Gold Dredging Co. The dredge output of gold in the county was $84,026 more in 1917 than in 1916. Considerable platinum was obtained during the dredging operations of the Natomas Co. Some gold was obtained by drift and surface placers near Folsom, and one deep mine near the same place had an output of gold.

SAN BERNARDINO COUNTY.

There was a decrease in the quantity of ore treated in San Bernardino County in 1917, as compared with 1916, and in the gold and zinc recovered, but an increase in copper, lead, and silver. The total decrease in 1917 in value of all metals produced was $129,476. The production of gold decreased $124,837. Silver increased 5,879 fine ounces; copper, 46,259 pounds; lead, 1,304,820 pounds; and zinc decreased 1,538,538 pounds. The output of gold was valued at $154,976.

The silver amounted in 1917 to 107,924 fine ounces, valued at $88,930; copper, 1,572,125 pounds, valued at $429,190; lead, 2,195,791 pounds, valued at $188,838; and zinc, 45,216 pounds, valued at $4,612. Two deep gold mines, nine copper mines, one silver mine, eight silver-lead mines, eight lead mines, and one placer mine, a total of 29, reported production in this county in 1917. There were 1,165 tons of siliceous ore sold or treated in 1917, 20,630 tons of copper ore, 366 tons of lead ore, 77 tons of silver ore, and 10,045 tons of silver-lead ore. No distinctively zinc ores were mined, the zinc being derived from other ores.

There were 31,283 tons of crude ore sent to smelters, which yielded $152,766 in gold and 107,394 fine ounces of silver, valued at $88,493. In addition 1,000 tons of old tailings were worked, which yielded $1,310 in gold and 528 ounces of silver, valued at $435. The copper ores produced 7,244.01 fine ounces of gold and 35,838 fine ounces of silver; the lead ores produced no gold, but 1,040 ounces of silver; the silver ores yielded 6.97 ounces of gold and 1,301 ounces of silver; the silver-lead ores 52 fine ounces of gold and 69,210 ounces of silver.

The War Eagle mine, at Bagdad, is a lead mine yielding some silver. The Bagdad-Chase, at Barstow, is equipped with a 50-ton cyanide plant, but it was worked for only two months of the year on tailings. The Goldstone Mining Co., at the same place, made a small output of lead. The Sagamore Mining Co. operated a silver-lead mine at Barnwell. The Copper World, at Cima, started a matte smelter of 100 tons capacity in November and its product was shipped to the smelter at Garfield, Utah. Other copper producers at Cima, are the Express & Domingo, and the Standard; and the lead producers are the New Era Mining Co. and Piute. The old Waterloo mine, at Daggett, made a small output, as did some few other silver claims at the same place. The Belle McGilroy, at Goffs, produced copper ore carrying considerable silver. Other producers at Goffs were the Bonanza King, Louisiana-California Mining Co., and Stemwinder Mining Co. The Bullion mine, at Ivanpah, yielded some copper ore; and silver-lead ore was derived from the Peterson lease, at Maruba. Ores carrying both copper and zinc were produced at the Emperor mine, at Nipton. The Carbonate King mine was operated for five months of the year and its ore was shipped from Roach, Nev. The Horn Copper Co., the nearest postoffice to which is Parker, Ariz., shipped some copper ore, as did the Denver Group at Silver Lake. The Pacific, at Stagg, was closed down from June to October, during which time a 150-ton concentrating mill was constructed. The company worked the Bagdad-Chase and Roosevelt mines during the rest of the year and made quite a large output of gold, silver, and copper. The Sunshine Copper Co., at the same place, produced copper ore only.

The Crystal Dome Mining Co., of Trona, shipped sulphide and carbonate of lead and a few tons of molybdite of lead during the year. The Minetta and Mohawk are producing silver-lead mines near Trona. A small quantity of copper ore was mined during assessment work by the Mount Whipple Gold Mining Co., of Vidal; and the Ibex Spring Mining Co. shipped ore carrying lead, zinc, and silver. The only dry-washing mine reporting production in the State was the Coolgardie Mining Co., 14 miles from Barstow. It was not operated commercially, but some gold was obtained by a hand dry-washer while assessment work was being done. The gold was taken from an ancient river bed formation.

SHASTA COUNTY.

The total value of the metallic output of Shasta County in 1917 was $9,218,396, which is $3,668,596 less than it was in 1916. The main decrease was in copper and zinc, but there was some decrease in gold also. The number of producing mines in the county was 23, or 7 less than in 1916. The output of gold was valued at $775,125, a decrease in 1917 of $161,760, as compared with 1916. The yield of silver in 1917 was 631,921 ounces, valued at $520,703, a decrease in quantity of 1,063,324 ounces and in value of $594,768. The output of copper in the county in 1917 was 26,658,879 pounds, valued at $7,277,874, a decrease of 13,100,593 pounds in quantity and of

$2,502,956 in value, as compared with 1916. The recoverable zinc was 6,320,529 pounds, valued at $644,694, a decrease of 1,543,695 pounds in quantity and of $409,112 in value, as compared with 1916. Shasta, notwithstanding its serious decrease in value for the year 1917, continues to be the leading county of the State in total value of metallic output. It also leads all other counties in the values of copper and zinc, but, for the first time in many years, its silver output has been exceeded by that of Inyo County.

The total number of deep mines from which production was reported in Shasta County in 1917 was 17, as against 21 in 1916. Of these 8 were gold mines, 1 was silver, and 8 were copper. The output of 494,469 tons of ore was made up of 9,673 tons of siliceous ore, 484,511 tons of copper ore, and 285 tons of silver ore. The placer mines of the county in 1917 yielded 14,054.78 fine ounces of gold, valued at $290,538. This production came from three dredges and three surface placers.

The gold from deep mines amounted to 23,441.90 ounces, valued at $484,587, and the silver to 630,635 fine ounces, valued at $519,643. The gold derived from siliceous ore amounted to 5,187.01 fine ounces, valued at $107,225, and that from copper ores to 18,254.89 ounces, valued at $377,362. The production of silver from siliceous ore was 9,674 ounces, valued at $7,971; from copper ores 617,295 ounces, valued at $508,651; and from silver ore 3,666 ounces, valued at $3,021. The siliceous ore, therefore, yielded $115,196 in gold and silver and the copper ores $886,013 in gold and silver.

The gold and silver mills in Shasta County in 1917 treated 864 tons of ore, which yielded in gold bullion $17,196 and 159 fine ounces of silver, valued at $131. The total recovery of mill bullion was valued at $17,327, or an average value per ton of $20.05 in gold and silver. This ore yielded 15 tons of concentrates with a gold value of $1,698 and a silver content of 27 ounces, valued at $22, a total value of concentrates of $1,720. In addition 101,173 tons of ore were shipped directly to concentrating mills from which 13,376 tons of concentrates were derived. The average value per ton of all concentrates was $0.21 in gold and $0.14 in silver in addition to copper content.

The crude ore sent to smelters, amounting to 392,432 tons, yielded (in addition to the copper) $464,556 in gold, an average of $1.18 a ton, and 628,083 ounces of silver, valued at $517,540, or $1.32 a ton. The total value of gold and silver recovered from ore sent to smelters was $982,096, or an average value of $2.50 a ton, as against an average of $3.29 a ton in 1916.

The National Potosi and Old Veteran mines, at Buckeye, were worked in a small way in 1917. The ore of the Ruby-Pearl mine, at Castella, is worked in a small mill on the property. The Balaklala Consolidated Copper Co., at Coram, operated 11 months of the year, but was closed the other month by reason of labor troubles. The mine is developed by adits totaling 10,000 feet in length and by 500 feet of diamond core drilling. The ore is a cupriferous pyrite, which is sold to the smelter of the Mammoth Copper Mining Co. at Kennett, there being no reduction works in operation at the mine. The Shasta Hills Mining Co., at French Gulch, owns a group of contiguous mines with development amounting to some 1,500 feet. The ore was treated at a custom mill in 1917, but later the company provided its own mill. Among other producers at French Gulch were the El Dorado and Eureka group, the Summit mine, and the Western Exploitation Co. The Afterthought Copper Co., at Ingot, produced copper, lead, zinc, and silver in 1917. The zinc concentrate was shipped to the Bartleville Zinc Co. and the copper concentrates to the Tacoma Smelting Co. The company has a 300-ton flotation mill running 24 hours when at full capacity. The Mammoth Copper Co. is the largest producer of copper, zinc, and silver in the State, and the yield of gold is also considerable. The total value of the output of this property is much greater than that of any other in California. The reduction plant consists of a smelter with five furnaces (of which three were in use), two converters, and a picking or sorting plant for zinc ores. Straight pyritic smelting is carried on, and the copper is shipped as blister to the refinery at Chrome, N. J. The copper plant and mine were regularly operated in 1917. The zinc was sorted at the smelter on a picking belt and shipped to Altoona, Iola, or La Harpe, Kans. A great deal of siliceous ore from various gold mines in the country was treated at the Mammoth smelter, and a considerable output of gold resulted. The Mountain Copper Co. (Ltd.), of Keswick, is a very large producer of copper and has some output also of gold and silver. The mines and mill were in operation approximately 11 months in 1917, and the smelting plant during the whole year. The smelter is at Martinez on the shores of San Francisco Bay, about 250 miles from the mines. The concentration mill of 500 tons daily capacity is at Minnesota, 5 miles from the mine. There are three contiguous mines, the Iron Mountain, Hornet, and No. 8 mine. The sulphide ore is roasted to manufacture sulphuric acid and then the calcines, with suitable mixture of other ores, are smelted in reverberatories. The copper matte carrying the gold and silver is converted to blister, which is shipped to the Baltimore Smelting & Rolling Co., Baltimore, Md. The Parker Metal Mining Co., near Redding, operates one of the few purely silver mines in the State. The Greenhorn Mountain Copper Co. is a productive copper property near Shasta. The Evening Star Mining Co., Whitehouse, produces considerable gold and silver. The Bully Hill Copper & Smelting Co., at Winthrop, reopened its mine in February, 1917, and ore shipments to the Mammoth smelter began in June. The Rising Star shaft was unwatered 400 feet, mine workings were reopened, and some new development was done. The property is opened by a 600-foot vertical shaft and about 10,000 feet of drifts. The mine is equipped with a 300-ton smelter (not used) and a railroad to Pitt, 17 miles long. Experiments are being made for the recovery of zinc. The Arps Copper Co. is a small producer of copper, silver, and gold at Ydalpom. A combustion-engine compressor plant was added to the equipment in 1917. The ore is sold to the Mammoth smelter at Kennett.

Of the placer mines in the county the most important are those operated by the three dredging companies. The Shasta Dredge Co. is working stream gravel with one dredge on Cottonwood Creek, a mile east of Gas Point. Lawrence Gardella operated a dredge on stream gravel at Clear Creek, near Redding, and was building another dredge at the same place. The Shasta Mining & Dredge Co. used one dredge in working stream and bench gravel on Cottonwood Creek. Some small placer mines were worked with small production near Redding, Taylor, and other points in the county.

SIERRA COUNTY.

The total production of metals in Sierra County in 1917 was valued at $386,057, as compared with $727,547 in 1916, a decrease of $341,490. The deep-mine gold decreased $332,028 and the placer gold $7,800. There were 49,779 tons of siliceous ore treated in gold and silver mills in 1917, yielding $320,728 in gold and 1,769 ounces of silver, valued at $1,458, a total of $322,186 in gold and silver. These ores also produced 1 ton of concentrates which yielded $343 in gold and 1 fine ounce of silver. In addition 170 tons of crude ore shipped to smelters yielded $1,634 in gold and 5 ounces of silver, valued at $4, a total of $1,638. There were also treated 93 tons of old tailings yielding $580 in gold and 2 ounces of silver, valued at $2, or an average of $6.25 a ton. The output of the placers of the county in 1917 was 2,957.79 ounces of gold, valued at $61,143 and 199 ounces of silver, valued at $164, a total of $61,307. Of the placer gold $29,710 came from hydraulic mines, $13,267 from drift mines, and $18,166 from surface placers. There were 30 productive mines in the county in 1917, of which 11 were deep gold mines. Of the 19 placers, 4 were hydraulic mines, 8 drift, and 7 surface placers.

The mine of the Croesus Gold Mining Co., Alleghany, has a 20-stamp mill, and the plant was operated throughout the year. Some of the arsenical ore from this mine is roasted before grinding. The mine of Mariposa Mine Association is opened by a 300-foot vertical shaft, a 700-foot adit, and about 1,000 feet of drifts. There is a 5-stamp mill on the property. The Original 16 to 1 Mine is opened by a 730-foot vertical shaft, a 200-foot adit, and 5,000 feet of drifts. A small ball mill is used to reduce the ore. Litigation hampered operations to some extent. The Durston Gold Mining Co. did not complete its 10-stamp mill until December, 1917, so that the output was small. The Twenty-One Mining Co. operated irregularly during 1917. The mine is developed by a main adit 1,940 feet long, with drifts, crosscuts, and raises aggregating 1,600 feet. There is a 10-stamp plate amalgamation mill on the property. The Tightner Mines Co. did 4,672 feet of development work in 1917. There is on the property a 20-stamp amalgamation and concentration mill, but the concentrates are "stacked" for future treatment. The El Dorado Mines Co. is among other small producers at Alleghany. The Cliff Leasing Co., a Milwaukee, Wis., corporation, operated the Oxford quartz mines at Downieville. The Mexican mine made a 10-stamp mill out of its old 5-stamp mill in 1917. The Four Hills Mining Co., at Johnsville, was worked by lessees for high-grade ore, which was crushed in a 2-stamp mill, though there is a 20-stamp mill on the property.

Of the few placers near Alleghany the Morning Glory mine made a small output. The Brandy City Mining Co. worked by hydraulic process ancient river bed gravels between Cherokee and Canyon Creeks, half a mile from Brandy City. The Depot Hill hydraulic mine, at Camptonville, had only a three months water season. The Orient, 6 miles from the same place, made a small output by hydraulicking ancient river gravel. The Grizzly Ridge drift mine, Downieville, breasted out some rim gravel, but the main channel deposit has not been reached by the bedrock tunnel. The Lassiat, Wide Awake drift, and some other placers reported small yields at or near Downieville. The Mugwamp Mines Co. has a tunnel 2,000 feet long, to which 200 feet was added in 1917, and some raise and crosscut work was also done. This company has a 50-ton ball mill tumbler to free converted gravel before washing in sluices. Considerable gold output was made by the Kirkpatrick Mining Co. by drifting an ancient river channel through a tunnel between Forest and Goodyear Bar. The Bope and the Confidence mines were among small producers at Pike. The Caledonia worked claims at Cedar Grove ridge between Slate and Canyon creeks. The Klondike drift mine at Sierra City had a small crew on development work the entire year, and some gold was recovered. The Pig Canyon mine sluiced out some gold at Sierra City with snow water. The Howland Flat Mines Co. and Winkeye (Table Rock Mining Co.) worked an ancient river bed by drift mining at Table Rock, operating 11 months in 1917. There was some gold produced from small placers at Sierra City, Scales, and other points in the county.

SISKIYOU COUNTY.

In 1917 Siskiyou County produced 15,748.48 fine ounces of gold, valued at $325,550; 20,489 ounces of silver, valued at $16,883; 896,846 pounds of copper, valued at $244,839; and 541,079 pounds of zinc, valued at $55,190, a total of $642,462. This was an increase of $192,201, as compared with 1916. There were 7 deep mines producing as compared with 11 in 1916. They produced 5,853 tons of ore, yielding gold valued at $22,461, and 19,068 ounces of silver, valued at $15,712, a total of $38,173, as compared with $55,636 in 1916. The 40 producing placer mines yielded gold valued at $303,089, and 1,421 ounces of silver, valued at $1,171, a total of $304,260, as compared with $387,983 in 1916. Thus it is seen that the placers yielded $266,087 more in gold and silver than the deep mines of the county. The number of producing mines (47) in Siskiyou County was larger than in any other county of the State, although there were 13 less than in 1916. Of the placers 32 hydraulic mines produced $101,920 in gold; the 3 dredges $182,855; the one drift mine and 4 surface placers $18,314. The hydraulic mines produced $36,257 less and the dredges $46,629 less gold in 1917 than in 1916.

Of the deep mines the Facey, at Callahan, produced considerable gold and a small quantity of silver. The Dewey Mines Co., at Gazelle, after an idleness of 10 years, started up and began using electricity on account of the high cost of wood for fuel. The mine is equipped with a 10-stamp amalgamation and concentration mill. The Polar Bear mine, at the same place, was only operated from September until the middle of November. The Blue Ledge copper mines in the extreme upper corner of the county, shipped ore to Tacoma, Wash., and also produced a large quantity of ore which was not marketed. Both copper and zinc, with considerable silver and some gold were produced by these mines. The Eureka & W. Y. O. D. property at Rollin, and the Oregonian Group at Sawyers Bar, were small producers of gold. The latter has a small 3-stamp mill. The Gipsy, at Yreka, produced a small amount of gold.

Of the placers the Baines and the Wendell, at Black Bear, sluiced out some gold. At Callahan, the Sugar Hill and some other mines produced in a small way. The Banner hydraulic, at Cecilville, had about a six months' run, and some other placers at the same place were producers. The Michigan Salmon Mining Co. worked bench gravel by hydraulicking for five months at Forks of Salmon, and there was some output from smaller placers at the same place. The Siskiyou Dredge Co. worked stream gravel on McAdams Creek near Fort Jones, with one dredge. A number of small placer mines in the same vicinity produced considerable gold during the year. The Sulphur Springs hydraulic operated in a small way at Gottville, and there were a few productive placers near Greenview. At Hamburg, the Morris hydraulic, Kunz Flat hydraulic, Nigger Creek, and some other smaller placers reported production. The Siskiyou Mines Co. worked gravel and sand by hydraulic process in the Klamath River, 6 miles from Happy Camp, for nine months of 1917. The South Fork, Squirrel Creek, and other placers were productive in the same region. There was also some output of placer gold at Hornbrook. The Frazier hydraulic in Eddy's Gulch, near Rollin, made a small output. At Sawyers Bar, the Forks of Salmon, Gold Hill, Cronin, Multum in Parvo, Thomain, Burns, and others were producing hydraulic mines. At Scott Bar, the Quartz Hill hydraulic mine was the principal producer. The Jack Lowden hydraulic, at Seiad Valley, Blue Nose hydraulic, at Blue Nose, some small placers at Somes Bar, and the Crary, at Walker, all produced more or less gold. The Klamath Dredging Co. used one dredge in working stream gravel on Klamath River bars near Walker. El Oro Dredge Co. operated one dredge on Greenhorn Creek, near Yreka, working stream gravel continuously throughout the year. Some smaller placers in that vicinity were also producers.

TRINITY COUNTY.

In 1917 Trinity County produced 29,124.07 fine ounces of gold, valued at $602,048, and 12,162 ounces of silver, valued at $10,021. The total value of all metals including copper was $968,307, an increase of $137,732 over 1916. The increase in gold was $166,555. Twenty-nine mines reported production in 1917, or 19 less than in 1916. Of these 3 were deep gold mines and 1 was a copper mine; and of the placers 17 were hydraulic, 4 were dredges, and 3 were surface placers. The deep mines produced from 8,801 tons of ore 1,008.91 fine ounces of gold, valued at $20,856, and 9,822 ounces of silver, valued at $8,093, a total of $28,949 in gold and silver, as compared with $66,261 in 1916, a decrease of $37,312. The ore treated was less by 4,858 tons than in 1916. The 25 placers yielded 28,115.16 fine ounces of gold, valued at $581,192, and 2,340 ounces of silver, valued at $1,928, a total of $583,120, and an increase of $206,297.

Of the deep mines very little output was made at the Brown Bear, at Deadwood, formerly the largest producer in the county. The Island Copper Co. in Island Mountain district, shipped ore carrying, in addition to the copper, considerable gold and silver for reduction to the smelter at Tacoma. The Five Pines and Surprise mines, at Trinity Center, made only a small gold output. The Foster Gold Mining Co. operated the Bonanza group of mines near Carrville; it is opened by a 2,300-foot adit and is the only "gravity" quartz gold mine in California—that is, the only mine with no pumping or hoisting. The present workings are 1,000 feet below the croppings.

There are some small producing placers at Big Bar; and at Burnt Ranch the McAtee Bar did a little hydraulicking. The Pacific Gold Dredge Co. is a new enterprise on Trinity River, 2 miles from Carrville, which carried on dredging for only 33 days in 1917. At Coffee are the Schlomberg and the Underground Treasure mines. The Slide Creek Mining Co. and a few other hydraulic mines made outputs at Denny, and there were some small placers working at Douglas City. At Hayfork, the Carrier Gulch, Murphy & Layman, and a few other mines were productive. The Chapman & Fisher, and Red Hill were producing hydraulic mines at Junction City. The Valdor Dredge Co. operated an electrically driven 7-foot bucket, California type of dredge, along Trinity River, 3 to 6 miles below Junction City, and was the most productive placer property in the county. Considerable gold was obtained from small placer operations in the vicinity of Junction City. The Bablew Mines Co. (hydraulic), Donnelly Gulch (drift), and Trinity Dredge Co. were the principal producers at and near Lewiston, but there was a considerable gold output from smaller properties. Some output was made by Mistake Nos. 1 and 2 mines in Bridge Gulch, 4 miles from Peanut, in Hayfork district. The Estabrook Gold Dredging Co. operated a 7½ cubic foot bucket dredge on stream gravel for 11 months in the vicinity of Trinity Center. The Horseshoe hydraulic mine worked on Kincaid Gulch, a tributary of Weaver Creek, a mile and a half from Weaverville, but they only had about one month's supply of water from December, 1916, to July, 1917. The La Grange Mining Co. near Weaverville, formerly the most productive hydraulic mine in the State, made considerable output of gold, but less than usual owing to lack of water supply. The Gem is a small hydraulic mine at Willow Creek.

TUOLUMNE COUNTY.

In Tuolumne County in 1917 there was a decrease of five in the number of producing mines and a decrease in both quantity of ore and the value of gold produced. The output of gold was 15,532.49 fine ounces, valued at $321,085; of silver 9,475 ounces, valued at $7,808, and of copper 12,000 pounds, valued at $3,276. The total value for the year was $332,169, a decrease of $553,107 as compared with 1916. The deep mines of the county produced 41,527 tons of ore which yielded 15,086.52 fine ounces of gold, valued at $311,866 and 9,450 ounces of silver, valued at $7,787, not including the copper. The total metal value from the deep mines was $322,929 as compared with $875,385 in 1916. There were 18 producing mines in the county in 1917, of which four were placers and 14 were deep mines. The three drift mines and one surface placer yielded 445.97 fine ounces of gold, valued at $9,219, and 25 ounces of silver, valued at $21, a total yield of $9,240.

The total quantity of ore sold or treated in the county in 1917 amounted to 41,527 tons, or 183,538 tons less than in 1916. There were treated 41,256 tons in gold and silver mills, yielding $233,866 in gold bullion, and 8,550 ounces of silver, valued at $7,045, a total in mill bullion of $240,911, or an average of $5.84 a ton in gold and silver. From the milling ore 1,585 tons of concentrates were obtained, which yielded $73,432 in gold and 890 ounces of silver, valued at $733, a total of $74,165 in gold and silver, and a total average yield of $46.79 a ton.

The ore milled and concentrated yielded a total value of $307,298 in gold and $7,778 in silver. The total yield of gold and silver on the plates and from the concentrates was valued at $315,076, or $7.64 a ton, as compared with $3.88 a ton in 1916.

In addition 218 tons of ore were sent to smelters, which yielded no gold or silver. There were also 35 tons of old tailings worked, which yielded a small output of gold and silver.

The great falling off in total output of gold in the county is readily accounted for by the idleness of the Harvard mine, at Jamestown, formerly a large producer and the materially reduced production of such prominent mines as the Dutch-Sweeney at Jamestown, Eagle-Shawmut at Shawmut, Black Oak at Soulsbyville, and Nyman at Stent, besides other smaller properties in the county and also in view of the lesser number of producers.

Of the deep mines of the county the Gold Bug & Little Wonder, at Big Oak Flat, made a small output. The Experimental Gulch mine, at Columbia, worked about eight months while water for power was available. On this property are two mills, one of 5 stamps and one of 3 stamps. The App (operated by the Dutch-Sweeney Mining Co.), at Quartz, is opened by an incline shaft 1,276 feet deep. The old mill has been dismantled and the ore was treated at the Dutch-Sweeney mill. The Dutch-Sweeney is opened by an incline shaft 2,207 feet deep. The main shaft was sunk 506 feet in 1917. The ore is treated by amalgamation, gravity concentration, and flotation. The Greenstone mine, at Quartz, produced a small quantity of copper. The Eagle-Shawmut Mining Co., at Shawmut, operated its plant to April 1, 1917. Mine development and mill reconstruction has been done since February, 1917, by the Tonopah-Belmont Development Co. The mine is opened by an incline shaft 2,250 feet deep from the face of the adit level 2,000 feet long. In 1917 the shaft was deepened 451 feet and 1,400 feet of drifting was done. The property is equipped with a 100-stamp amalgamation and concentration mill and a 22-ton chlorination plant. The ore is treated by stamping, amalgamating, concentrating, and chlorinating by barrel treatment after roasting. The deep mine producers of Sonora are the Hope Mining Co., Sugarman, and a number of smaller properties. At Soulsbyville, are the Addis and the Black Oak. On the latter mine is a 100-ton cyanide plant. The ore is crushed in solution, and reground in a tube mill, followed by Pachuca agitation, continuous filtration, and zinc-dust precipitation. The Jumper-California, at Stent, was operated continuously during the year on the leasing system. The mine is opened by a 1,450-foot incline shaft and a 500-foot vertical shaft. The Nyman Consolidated Mines Co., at Stent, ceased all work in September, 1917. The mine is opened by a vertical shaft 850 feet deep, an adit 100 feet long, and some 15,000 feet of drifts. The reduction plant consists of a 20-stamp amalgamation and concentration plant. On the Star King mine, at Tuolumne, only one month's work was done in 1917, when operations ceased. The mine is opened by an incline shaft 565 feet deep, and has a 5-stamp amalgamation and concentration mill.

Of the placers producing in the county the Saratoga is a drift mine at Columbia, and there are some few placers at Columbia and near Jamestown.

YUBA COUNTY.

Yuba County in 1917 was second in relative rank among gold-producing counties of the State, being exceeded only by Nevada County, where deep quartz mines predominate. Yuba County in 1917 produced more placer gold than any other county in California, almost entirely from its extensive dredging operations. The output of the county in 1917 was $3,677,673 in gold and 7,999 ounces of silver, valued at $6,591, a total of $3,684,264 in gold and silver, and an increase of $510,607, as compared with 1916. The dredges in 1917 produced $3,659,211 in gold, which is $519,061 more than in 1916. Twelve dredges were in operation in the county in 1917, and, including these dredges, there were 21 productive placers.

The Yuba Consolidated Gold Fields, operated by the Hammon Engineering Co., in Yuba river, near Hammonton, is the most extensive dredging enterprise in the county and in the United States. It had 9 dredges working the full 12 months of 1917. The Marysville Dredging Co. operated 3 dredges the whole year on the old gravel plain deposited by Yuba River near Marigold. Both these dredging companies obtained considerable platinum with their gold. Other producing placers in the county were the Bright Star and Landers Bar at Browns Valley, some small mines at Dobbins, Archimedes at Marysville, and Julius Cæsar drift at Smartsville.

OTHER COUNTIES.

Fresno County.—This county produced in 1917 metals valued at $15,043, of which $5,745 was gold; and there were 351 ounces of silver, valued at $289; and 33,000 pounds of copper, valued at $9,009. The Copper King Mining Co., of Clovis, shipped its ore to the International Smelter, Utah; Garfield Smelter, Utah; Mammoth Smelter, Kennett, Cal.; and Tacoma Smelter, Tacoma, Wash. Before the end of 1918 the company expects to be shipping 50 tons of ore daily. The Imperial Copper Co. was a small producer of copper at Clovis. Small quantities of gold were produced by the Sunnyside mine, at Piedra, and the M & M Co., at Dunlap. The Grant Rock & Gravel Co. operates a gravel plant in San Joaquin River at Friant, but saves considerable gold by sluicing in the gravel washing plant which does not interfere with the gravel operations.

Imperial County.—This county produced $919 in gold, 6 fine ounces of silver, valued at $5, and 7,000 pounds of copper, valued at $1,911, the total value of the metals being $2,835. The few producing mines are at Ogilby.

Merced and Stanislaus counties.—In these counties there were two dredge companies and one surface placer operating in 1917, with a combined gold output of about $21,000 less than in 1916.

Riverside and San Diego counties.—Only two mines operated in these counties in 1917, one in each, making a combined output valued at $5,585.

GOLD, SILVER, COPPER, AND LEAD IN OREGON.

(MINES REPORT.)

By CHARLES G. YALE.

INTRODUCTION.

The total metal output of Oregon decreased in value more than 22 per cent in 1917, as compared with 1916. Much of this deficit was due to the lessened yield of the larger deep mines of the State, the principal ones reporting a much smaller production than in 1916. From only a few mines was an increased output reported.

The gold mining industry in Oregon was affected unfavorably by the same conditions as in other Western States during 1917. Prices of supplies increased materially, and skilled labor was high and scarce. There has been, for these reason, a certain curtailment of operations involving decreased outputs, especially in most of the deep mines. Moreover, the value of the siliceous ore obtained from the deep mines declined 66 cents a ton in average value in 1917, as compared with 1916, and the quantity of such ore treated or sold was about 24,000 tons less. All the larger copper properties except two showed a decreased output in both quantity and value. The older dredging fields of the State showed a material decline in production of gold, and one dredge was idle at the end of 1916, the profitable ground having been exhausted. Two new dredges were put in operation during 1916 and 1917 and are working profitably in new areas. Very few new gold or copper mining enterprises were inaugurated in Oregon in 1917 and none of any magnitude. The State evidently must have outside capital to develop the better known districts and to assist prospectors in searching for new deposits.

As the gold mining industry is at present in a depressed condition, there seems to be little incentive for investment in properties of this character, and until the end of the war it is not probable that many new mines of any size will be developed and equipped. Nevertheless, there are, in Oregon, quite a number of mines which could be made much more productive if additional capital were available. At the present time there are few large mining enterprises being carried on productively in Oregon. The deep mines which have an annual production exceeding $100,000 are those of the Baker Mines Co., Cornucopia Mines Co., Homestead Iron Dyke Co., and Queen of Bronze Mining Co. The only placers exceeding the figure named in value of output are the Powder River Gold Dredge Co. and the Empire Gold Dredge Co.

The southwestern counties of Oregon,[1] which form an extension of the California gold belt, are Benton, Coos, Curry, Douglas, Jackson, Josephine, and Lane. These counties (with the exception of Benton, which reported no production) reported in 1917 a combined production of $117,075 in gold, and 758 ounces of silver, valued at $625. The production of placer gold in this regiou in 1917 was $90,017, a decrease of $41,310, and the production of gold from deep mines was $27,058, a decrease of $13,904. The total decrease in output of gold in these southwestern counties in 1917, as compared with 1916, was, therefore, $55,214. The output of gold in Coos County was slightly increased by the placers. In Curry County the decrease of about $6,800 was all from the placers. Two of the largest hydraulic mines at Marial were idle, one at Port Orford did assessment work only, and one at Wedderburn went out of business. There was little difference in the output of the mines in Douglas County in 1917 and 1916. From Jackson County the deep mines all reported reduced returns. Of the placers one mine at Layton showed some increase, but at Rogue River, Jacksonville, and Medford the returns were less from placer mines. The largest proportion of the decrease of the county was from Jacksonville. Of the deep mines of Josephine County the largest producer at Galice in 1916 was idle in 1917. With one exception the deep mines at Takilma showed increase in output of both gold and copper. Of the placer mines of Josephine County, the largest producer at Holland in 1916 was abandoned during 1917. Most of the placers at Galice, Leland, Kerby, Merlin, Waldo, and Grants Pass showed reduced outputs of gold as compared with 1916. In Lane County the largest producer of 1916 showed a reduced output for 1917.

Northeastern Oregon comprises the counties of Baker, Crook, Grant, Harney, Malheur, Umatilla, Union, Wallowa, and Wheeler. In 1917 no metallic output was reported from Harney, Umatilla, Union, or Wallowa counties. The combined gold output of the five producing counties in this region in 1917 was $1,374,723, of which Baker County contributed $1,228,199, or 90 per cent. There was a decrease for 1917 in these counties, as compared with 1916, of $353,494. The yield of placer gold in 1917 was $637,349, a decrease of $103,841, or 14 per cent. The lode mines produced in gold $737,374 in 1917, as compared with $987,027 in 1916, a decrease of $249,653, or 25 per cent. It may be also stated that there was a decrease from this source of 27 per cent in 1916, as compared with 1915. The total decrease of gold output in this region in 1917, as compared with 1916, was $353,494. The greatest decrease in gold in any county was in Baker—$412,427. Only one county, Grant, showed an appreciable increase in 1917. As to the deep mines of Baker County, all the larger properties in the Cornucopia district showed very material decrease in yield of gold. The same may be said of both deep and placer mines in the Cracker Creek district, one deep mine which was a large producer in 1916 having been closed entirely at the end of that year. The Mormon Basin district also shows a material decrease from its principal gold mines. At the mines at Homestead there was an increase in gold, but a decrease in copper. There were fewer "small mines" operating in Baker County in 1917 than in 1916, so far as returns show. One dredging company at Bridgeport had a material increase, but the placers at Robinette, Rye Valley, and Home produced less than usual. There was very little difference in the output in Crook County for 1917 and 1916. In Grant County the principal deep mine at Granite showed a material increase in the output of gold, as did the dredging operations in the John Day district. Although there was some falling off in the output of the smaller mines, the large increase in the districts named resulted in the county being the only one in Oregon that increased its yield of gold in 1917. In Wheeler County the production was about the same in 1917 as in 1916.

---

[1] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 9–127, 1914. Diller, J. S., and Kay, G. F., Mines of the Riddles quadrangle, Oreg.: U. S. Geol. Survey Bull. 340, pp. 134–152, 1908.

PRODUCTION.

GENERAL STATEMENT.

Gold, silver, copper, and lead produced in Oregon, 1907–1917.

Year.	Number of mines producing.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	
1907	206	110,698	$1,129,261	86,718	554,104	....	$1,297,316
1908	239	50,684	865,076	43,602	291,377	2,138	926,737
1909	162	59,281	781,964	27,827	235,000	400	827,001
1910	180	82,132	679,488	35,978	13,861	....	700,676
1911	176	98,558	633,407	45,221	93,136	....	669,016
1912	210	90,945	770,041	57,081	260,429	39,317	849,886
1913	173	155,901	1,627,710	179,036	43,330	87,207	1,746,402
1914	105	124,331	1,591,461	142,552	39,248	16,436	1,676,153
1915	95	155,791	1,861,796	117,947	451,172	62,957	2,003,509
1916	108	159,071	1,902,179	231,342	3,581,886	28,000	2,937,478
1917	76	142,438	1,491,798	125,656	[illegible]74,487	....	2,270,874
Decrease	−32	−16,633	−410,381	−105,686	−1,107,399	−28,000	−666,604

The total metal output of Oregon decreased in value $666,604 in 1917, as compared with 1916. The quantity of ore treated decreased 10.4 per cent; the gold decreased 21.5 per cent in value; the silver decreased 45.6 per cent in quantity; the copper decreased 31 per cent in quantity; and no production of lead was reported.

The mine production of Oregon, having a total value of $2,270,874 in 1917, was derived from 76 producing mines, of which 53 were placer and 23 were deep. The producing placers which reported decreased in number by 22 in 1917 and the producing deep mines by 10. The total quantity of ore sold or treated was 142,438 short tons, a decrease of 16,633 tons. This ore averaged $6.05 a ton in gold and silver, aside from copper, as compared with $7.39 a ton in gold and silver in 1916.

GOLD.

The total recoverable gold content of ores and the gold from placers in Oregon in 1917 was 72,165.73 fine ounces, valued at $1,491,798, a decrease of 19,852.18 fine ounces in quantity and of $410,381 in value. The largest yield of gold from one county was $1,228,199 and came as usual from Baker County and was a decrease of $412,427, as compared with the yield in 1916. The next county in rank of production of gold was Grant, with $137,720, or an increase of $74,127, due almost entirely to dredging operations. Other counties in relative rank of production as named were Josephine, Douglas, Jackson, Crook, Lane, Malheur, Coos, Curry and Wheeler. The placer mines of the State produced $727,366 in gold in 1917, as compared with $872,517 in 1916, a decrease of $145,151. The hydraulic mines produced $106,991 in 1917, or $57,557 less than in 1916; the drift mines, $1.350 or $3,082 less; the surface placers and dredges combined $619,025, or $84,512 less. There were 46 hydraulic mines in 1917, as compared with 61 in 1916; and 4 dredge, 2 drift, and 1 surface placer mines were productive in 1917.

The total output of gold from deep mines in 1917 was 36,979.40 fine ounces, valued at $764,432, which was 12,830.50 ounces less in quantity and $265,230 less in value than in 1916. Of the gold derived from deep mines, $207,534 was recovered by amalgamation, $520,805 by cyanidation, and $36,093 by smelting. There were no chlorination plants in operation in Oregon in 1917, and the concentrates obtained in milling operations were shipped generally to smelters for treatment.

Mine production of gold in Oregon in 1917, in fine ounces.

County.	Placers.	Deep mines.				Grand total.
		Siliceous ore.	Copper ore.	Lead ore.	Total.	
Baker	25,010.65	33,124.49	1,278.99		34,403.48	59,414.13
Coos	48.37					48.37
Crook		290.01			290.01	290.01
Curry	4.98					4.98
Douglas	1,080.65					1,080.65
Grant	5,685.22	976.98			976.98	6,662.20
Jackson	839.45	16.98			16.98	856.43
Josephine	2,381.12	49.97	1,146.00		1,195.97	3,577.09
Lane		95.98			95.98	95.98
Malheur	91.53					91.53
Marion						
Wheeler	44.36					44.36
	35,186.33	34,554.41	2,424.99		36,979.40	72,165.73
Increase or decrease	−7,021.68	−12,860.69	+190.17	−159.98	−12,830.50	−19,852.18

Value of placer gold produced in Oregon in 1917.

County.	Hydraulic.	Drift.	Dredging.	Surface placers.	Total.
Baker	$12,535	$350	[a]$618,922		$631,807
Coos		1,000			1,000
Curry				$103	108
Douglas	22,339				22,339
Grant	2,733				2,733
Jackson	17,353				17,353
Josephine	49,222				49.222
Malheur	1,892				1,892
Wheeler	917				917
	106,991	1,350	618,922	103	727,366

[a] Includes dredging in Grant county.

SILVER.

The recoverable silver content of ores and the silver from placers in Oregon in 1917 aggregated 125,656 fine ounces, valued at $103,541, a decrease in quantity of 105,686 ounces and in value of $48,682.

Baker County in 1917 made the largest output of silver, 100,668 fine ounces, valued at $82,950. Grant County produced 23,052 fine ounces, valued at $18,995. The placer mines of Oregon produced 7,160 fine ounces, valued at $5,900, as compared with 9,249 ounces, valued at $6,086, in 1916. The deep mines produced 118,496 fine ounces, valued at $97,641; of this quantity 31,375 ounces were derived from copper ores, and the remainder, 87,121 ounces, from siliceous ore. By amalgamation 57,160 ounces, valued at $47,100, were recovered and 36,237 ounces, valued at $29,859, by cyanidation. At the smelters 25,099 ounces, valued at $20,682, were recovered.

Mine production of silver in Oregon in 1917, in fine ounces.

County.	Placers.	Deep mines.				Grand total.
		Siliceous ore.	Copper ore.	Lead ore.	Total.	
Baker	6,263	63,092	31,313		94,405	100,668
Coos	2					2
Crook		1,160			1,160	1,160
Curry	1					1
Douglas	63					63
Grant	518	22,534			22,534	23,052
Jackson	87	2			2	89
Josephine	208	5	62		67	275
Lane		328			328	328
Malheur	13					13
Marion						
Wheeler	5					5
	7,160	87,121	31,375		118,496	125,656
Decrease	2,089	31,022	72,447	128	103,597	105,686

COPPER.

The mine production of copper in Oregon in 1917 was 2,474,487 pounds, valued at $675,535, as compared with 3,581,886 pounds, valued at $881,144 in 1916, a decrease for 1917 of 1,107,399 pounds in quantity and of $205,609 in value.

MINING INDUSTRY.

Gold and silver produced in Oregon in 1917, by methods of treatment.

County.	Ore to gold and silver mills.			Ore to concentrating mills.	Concentrates produced.			Crude ore to smelter.		
	Quantity.	Gold.	Silver.		Quantity.	Gold.	Silver.	Quantity.	Gold.	Silver.
	Short tons.		*Fine ounces.*	*Short tons.*	*Short tons.*		*Fine ounces.*	*Short tons.*		*Fine ounces.*
Baker	93,397	$675,855	57,266	36,676	7,522	$26,439	31,256	126	$3,556	903
Crook								218	5,995	1,160
Grant				4,600	233	20,196	22,534			
Jackson	20	351	2							
Josephine	16	165	1					6,347	24,558	66
Lane								24	1,984	328
Marion								5		
	93,433	676,371	57,269	41,276	7,755	46,635	53,790	6,720	36,093	2,457
Average per ton		$7.24	0.612			$6.01	6.93		$5.37	0.365

There were treated at gold and silver mills in 1917 in Oregon, 93,433 tons of ore, yielding $676,371 in gold, and 57,269 ounces of silver, valued at $47,190. From 41,276 tons of ore sent to concentrating plants were recovered 7,755 tons of concentrates, having a value in gold of $46,635 and 53,790 ounces of silver, valued at $44,323, a total of $90,958. Crude ore shipped to smelters amounted to 6,720 tons, and contained $36,093 in gold and 2,457 ounces of silver. The 43,041 tons of copper ore shipped yielded 2,474,487 pounds of copper, or an average of about 57.5 pounds a ton. There were 1,009 tons of old tailings treated in 1917, yielding $5,333 in gold and 4,980 ounces of silver, valued at $4,104, or $9.35 a ton, in gold and silver.

Ore sold or treated in Oregon in 1917, in short tons.

County.	Siliceous ore.	Copper ore.	Lead ore.	Total ore.
Baker	94,434	36,774		131,208
Crook	218			218
Grant	4,600			4,600
Jackson	20			20
Josephine	101	6,262		6,363
Lane	24			24
Marion		5		5
	99,397	43,041		142,438
Increase or decrease	−24,216	+7,632	−49	−16,633
Value per ton in gold and silver	$7.91	$1.76		$6.05

Mine production of gold, silver, and copper in Oregon in 1917.

County.	Ore.	Quartz gold.		Placer gold.		Total.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.	*Fine ounces.*		*Fine ounces.*		*Fine ounces.*	
Baker	131,208	34,403.48	$711,183	25,010.65	$517,016	59,414.13	$1,228,199
Coos				48.37	1,000	48.37	1,000
Crook	218	290.01	5,995			290.01	5,995
Curry				4.98	103	4.98	103
Douglas				1,080.65	22,339	1,080.65	22,339
Grant	4,600	976.98	20,196	5,685.22	117,524	6,662.20	137,720
Jackson	20	16.98	351	839.45	17,353	856.43	17,704
Josephine	6,363	1,195.97	24,723	2,381.12	49,222	3,577.09	73,945
Lane	24	95.98	1,984			95.98	1,984
Malheur				91.53	1,892	91.53	1,892
Marion	5						
Wheeler				44.36	917	44.36	917
	142,438	36,979.40	764,432	35,186.33	727,366	72,165.73	1,491,798

County.	Quartz silver.		Placer silver.		Total silver.		Copper.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Fine ounces.		*Fine ounces.*		*Fine ounces.*		*Pounds.*		
Baker	94,405	$77,790	6,263	$5,160	100,668	$82,950	1,386,271	$378,452	$1,689,601
Coos			2	2	2	2			1,002
Crook	1,160	956			1,160	956			6,951
Curry			1	1	1	1			104
Douglas			63	52	63	52			22,391
Grant	22,534	18,568	518	427	23,052	18,995			156,715
Jackson	2	2	87	72	89	74			17,778
Josephine	67	55	208	171	275	226	1,087,216	296,810	370,981
Lane	328	270			328	270			2,254
Malheur			13	11	13	11			1,903
Marion							1,000	273	273
Wheeler			5	4	5	4			921
	118,496	97,641	7,160	5,900	125,656	103,541	2,474,487	675,535	2,270,874

PRODUCTION BY COUNTIES.

BAKER COUNTY.

The total value of all metals mined in Baker County in 1917 was $1,689,601, as compared with $2,428,503 in 1916, a decrease of $738,902. The production of gold from deep mines in 1917 decreased $267,368, silver 111,002 ounces, and copper 1,245,456 pounds, as compared with 1916, a total decrease in value from deep mines of $593,689. The placer mines of the county produced $517,016 in gold in 1917, or $145,059 less than in 1916. The placer silver produced in 1917 was 6,263 ounces, valued at $5,160, a decrease in value of $154 for the year. There were 21 producing mines of all kinds in the county in 1917, as compared with 27 in 1916. The number of producing deep mines was 11 and of placer mines 10. The total output of siliceous ore mined and treated in the county in 1917 was 94,434 tons, or 25,737 tons less than in 1916. The gold from this ore was valued at $684,744, and the silver amounted to 63,092 ounces, valued at $51,988. The average recoverable value of the ore per ton in gold and silver was $7.79. The 93,397 tons of siliceous ore treated at gold and silver mills produced $675,855 in gold and 57,266 fine ounces of silver (valued at $47,187), an average per ton of $7.74 in gold and silver. From the 36,676 tons of ores concentrated were derived 7,522 tons of concentrates producing $26,439 in gold and 31,256 ounces of silver (valued at $25,755), a total value of $52,194, or an average value per ton of $6.93. The total yield of the 130,073 tons of milling ore from the plates, from direct cyanidation, and from the concentrates, was $702,294 in gold and $72,942 in silver, an average per ton in gold and silver of $5.96. In addition 126 tons of ore were shipped to smelters and yielded in gold $3,556 and in silver 903 ounces, valued at $744, a total value of smelting ores of $4,300 in gold and silver, or an average value per ton of $34.12, exclusive of the value of the copper. There were also 1,009 tons of old tailings treated, which yielded $5,333 in gold and 4,980 ounces of silver (valued at $4,103), or $5.28 a ton in gold and $4.06 a ton in silver.

Baker district.—No deep mines and only one placer reported product from this district in 1917. The old Clark Creek Farm Co. sold part of its holdings at the confluence of Clark Creek and Burnt River to the Oregon Dredging Co., which in the summer of 1917 installed a flume dredge and operated it for about two months of the year. The remainder of the Clark Creek Farm is held under option by the same company and is being prospected with a view of purchase.

Cornucopia district.—This district is third in order of rank of output among the productive mining districts of Oregon. The four deep mines produced metals valued at $421,107 in 1917, of which $370,460 was for gold, $50,051 was for silver, and the remainder for a small quantity of copper. The most important mine of the district is that of the Baker Mines Co., and next in productive rank are the properties of the Cornucopia Mines Co., of New York. The Queen of the West Mines Co. operated its mine and 50-ton cyanide plant and concentrating mill from April until the end of October. The ore is crushed in a cyanide solution, the concentrates taken out on a vanner, reground, and treated in an agitating plant. On the Connor Creek Co.'s property work was done the entire year, but the mill was only run for three months. The plant consists of a 10-stamp amalgamating and concentrating mill.

Cracker Creek district.—The productive mines in this district consist of 1 deep mine, 1 drift mine, and 2 gold dredge mining properties, which made a combined yield in 1917 of $501,069, of which $495,974 was for gold, making this the most productive of the Oregon mining districts, exceeding the total yield of either the Cornucopia or Iron Dyke districts. The Whited is the only deep mine in the district and was worked under a lease and had a small output. The Surprise is a drift mine, which was only operated for three months of the year. The most important mining enterprise in the district (and in Oregon) is that of the Powder River Gold Dredging Co., which had two dredges operating in 1917, one of which ceased work at the end of the year.

Homestead district.—There was only a nominal output from this district in 1917, made by a deep mine, the Snake River Mining Co.

Iron Dyke district.—The property of the Homestead Iron Dyke Mines Co. (Inc.), next to that of the Powder River Gold Dredging Co., the most productive in Oregon, is located in this district. Most of the values from the mines are in copper. The Arkansas mine, in the same district, made a small production in 1917.

Mormon Basin district.—The deep mines in this district are the Commercial Mining Co., and the Deer Creek, and, in addition to the Rye Valley placers, there are several other smaller hydraulic mines. The total output of the district in 1917 was $315,504, of which $313,588 was for gold and the remainder for silver. The Commercial Mining Co., the most important in the district, is working the Rainbow mine, on which is a 100-ton cyanide plant, with a mill and amalgamation plant. The Deer Creek, another deep mine, was a small producer.

Pine Creek district.—In this district the following hydraulic mines made some output in 1917: Bull Dog, Cow Creek, Hamm Gold Mining Co., and some smaller claims.

Weatherby district.—The Little Hill Quartz mine operated in this district in 1917 in a small way. There is a 2-stamp mill on the claim.

COOS, CROOK, AND CURRY COUNTIES.

The only property reporting output from Coos County in 1917 was the Eagle mine, near Bullards. This is a "beach sand" drift mine where the "black sand" is about 8 feet deep. In addition to the gold, this mine produced a larger quantity of platinum than any other Oregon mine in 1917. In Crook County the only mine reporting product was the Ophir Mayflower Mining Co. (deep), in Howard district. This mine has a 5-stamp mill and concentrating plant.

In Curry County the Kalamazoo beach sand mine, near Wedderburn, in Denmark district, made a small output by sluicing.

DOUGLAS COUNTY.

This county produced $22,391 in gold and silver in 1917, all from hydraulic mines in Coffee Creek, Green Mountain, and Myrtle Creek districts. The water season was a poor one and some of the mines were only operated from 30 to 40 days. The productive placer mines were the Farquhar, Midget, Boulder, and a few more smaller ones.

GRANT COUNTY.

The production of Grant County in 1917 was $137,720 in gold and 23,052 ounces of silver, valued at $18,995, a total of $156,715, or an increase of $91,774 over the production in 1916. This output was derived from 1 deep and 5 placer mines. The placers are mostly in Canyon district, and the principal one is the Empire Gold Dredge, at John Day. Hydraulic mines producing were the Caledonia, Quartz Gulch, Maise Ridge, and some smaller ones. The only deep mine reporting production was the Ben Harrison, in Granite district which is developed by an 800-foot crosscut intersecting the vein at a depth of about 450 feet, the vein is opened to a further depth of 100 feet by a shaft. The reduction plant consists of a 20-stamp mill with concentrators and flotation plant, but the stamps are being replaced by a ball mill.

JACKSON COUNTY.

The total output of Jackson County in 1917 was $17,778 in gold and silver, derived from 2 deep mines and 8 hydraulic properties. A decrease of $25,350 is shown in the total yield, as compared with the year 1916. The two small deep mines are the Gold Ridge in Kanes Creek district and Pearl Mining Co. in Pearl district. The hydraulic mines of the county had a very short water season, which accounts for the falling off in gold yield for the year. The producing hydraulic mines were the Pacific Placer Co. (formerly the Layton) in Applegate district; Pearce Mining Co., Spaulding Mining Co., and Sterling Mining Co., in Forest Creek district; and Duffield & Burns in Galls Creek district. Several smaller operators made small outputs in each of the districts named.

JOSEPHINE COUNTY.

The total output of gold, silver, and copper in Josephine County in 1917 was valued at $370,981, as compared with $336,157 in 1916, an increase of $34,824, this increase being entirely due to the quantity and value of the copper produced. In 1917 the gold yield was $73,945; the silver was 275 ounces, valued at $226. The deep mines of the county produced from 6,363 tons of ore, $24,723 in gold and 67 ounces of silver, valued at $55, but the largest values were in copper. The total output of placer gold in the county, valued at $49,222, was derived from hydraulic mines, and was $15,442 less than the placer production in 1916. The decrease in total gold yield of the county in 1917, as compared with 1916, was $20,536. With the exception of a very small quantity all the ore produced in the county in 1917 was treated at smelters; and a very large proportion of the gold and silver from the deep mines was obtained in the smelting of copper ores.

The producing hydraulic mines in the Althouse district were the Goldsby, Little Gem, and Surprise.

The Corliss & Dean and a few other small hydraulic mines or placers were the only producers in the Galice district. The Almeda Consolidated Mines Co., formerly a large producing deep mine in this district, made no output in 1917.

From the Grave Creek district the only property reporting production was the Goff-Abbott hydraulic mine. The Archer and the Norton mines, both producers in 1916, were idle in 1917.

Four deep and two hydraulic mines reported production from Josephine district in 1917. The Anderson, on Illinois River, was the most productive hydraulic mine and made also a considerable output of platinum. This mine had a four months run, which was larger than most of the hydraulic mines in Oregon reported for the year. The other hydraulic mine in this district reporting production was the Gold Leaf group, near Kerby. The most important deep mine was the Queen of Bronze copper mine, at Takilma, which is opened by three tunnels, and on which about 600 feet of drifts and 350 feet of raises were made during the year. The product of this mine, after hand sorting, is shipped to the Tacoma smelter. The mine was operated with 36 men continuously during 1917. Considerable gold is contained in the copper ore from this mine, but very little silver. The Waldo is operated chiefly by open cut or quarrying method. The ore, carrying mainly copper, with some gold and very little silver, is treated at the Tacoma smelter. The mine was operated most of the time during 1917. The Waldo Copper Co., at Takilma, has a jig plant of 40-ton capacity. The reduction process is water concentration, jigs, Frue vanners, Standard tables, and Pinder concentrator. The concentrates are sold to the smelter. The St. Lilly and Diamond Drill mines made a small output of copper. The total value of the output of this district in 1917 was $327,903.

In the Jump-off-Joe district the Hydraulic Mining Co. is operating a hydraulic mine on upper Jump-off-Joe Creek. This was formerly known as the Cook & Howland mine. The Swastika hydraulic claims are on Jump-off-Joe, Jacks, and Horse creeks in this same district. The Ohio No. 5 and some smaller hydraulic mines are also operating in this district.

In the Pickett Creek district the only producers were the Farrer and a few other small hydraulic mines. In the Placer district the Columbia Mines Co. operated an extensive hydraulic mine and there were a few smaller ones reporting production. In the Sucker Creek district the January First, a deep mine, made a small output. The Fry Gulch and Osgood hydraulic mines were the only producers in Waldo district. The Blue Channel hydraulic is the only placer mine reporting from the Wolf Creek district; and the Thompson group was the only deep mine.

LANE, MALHEUR, MARION, AND WHEELER COUNTIES.

In Lane County the West Coast Mines Co., in the Bohemia district, whose property is extensively developed by adits and drifts and is equipped with a 30-stamp mill and concentrating plant, did very little beyond making repairs during 1917. In Malheur County the Boswell hydraulic and a few other placers in the Malheur Basin district were the only producers. In the Elkhorn district, Marion County, the Consolidated Copper & Power Co. was the only producer. The only mines reporting production from Wheeler County were the Mule Gulch and Sand Gulch hydraulic mines, in the Spanish Gulch district.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN NEVADA.[1]

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

GENERAL STATEMENT.

Mines in Nevada in 1917 produced 6,473,519 tons of ore, which, with placer bullion, contained gold, silver, copper, lead, and zinc valued at $54,424,580. This total represents an increase in value of $4,478,156, as compared with $49,946,424 in 1916 from 5,941,165 tons of ore and placer bullion. There were 943 producers of ore and bullion in 1917, of which 91 were placers, against 714 lode producers and 65 placers in 1916. The value of the production of copper represented nearly 62 per cent of the total value, or $33,522,954, an increase of $7,664,218. There was a decrease in the value of the production of recoverable zinc from $4,347,387 in 1916 to $2,275,402 in 1917. Silver decreased in quantity, but increased in value, owing to a higher price. The production of gold from all sources in 1917 was valued at $6,959,468, against $8,866,237 in 1916, a decrease of $1,906,769, or more than 21 per cent. The gold from placer mines decreased from $354,313 in 1916 to $292,584 in 1917. Sixteen mining companies in Nevada, some of which owned property in other States, paid dividends in 1917 amounting to $11,899,557.

Mine production of gold, silver, copper, lead, and zinc in Nevada, in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc.	Total value.[a]
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	779	5,941,165	$8,866,237	13,837,525	105,116,813	25,637,278	32,443,189	$49,946,424
1917	943	6,473,519	6,959,468	11,269,969	122,794,704	27,677,928	22,307,868	54,424,580
Increase or decrease, 1917	....	+532,354	−1,906,769	−2,567,556	+17,677,891	+2,040,650	−10,135,321	+4,478,156
Total, 1904–1917	....	46,358,897	161,538,140	156,240,386	743,868,871	161,609,267	135,987,572	411,098,218

[a] Includes placer production.

---

[1] The statistical tables of this report were compiled by Bessie N. Patchell, of the United States Geological Survey.

ORE.

Nevada mines produced 6,473,519 short tons of ore in 1917, an increase of 532,354 tons, compared with the production of 1916. The average total metallic value per ton was $8.36, against $8.35 in 1916, but the value per ton in gold and silver decreased from $2.96 in 1916 to $2.46 in 1917. The largest decrease in production of ore was in Churchill, Nye, Esmeralda, Clark, and Elko counties. The output of dry or siliceous ores decreased from 1,688,661 tons in 1916 to 1,413,929 tons in 1917. Under this classification for 1917 are included 589,228 tons of low-grade siliceous gold ores, averaging $6.03 in gold and 0.91 ounce of silver per ton, and carrying small quantities of copper and lead. Gold and silver mixed ores, dry or siliceous in character, aggregated 17,614 tons and averaged per ton $3.64 in gold and 5.46 ounces of silver. The output of siliceous silver ores in 1917 amounted to 807,087 tons, mined by 130 producers, averaging per ton $2.40 in gold and 11.83 ounces of silver, and carrying small quantities of copper and lead, as against 858,231 tons, mined in 1916 by 117 producers, whose ore averaged per ton $2.77 in gold and 13.94 ounces of silver. A total of 123,588 tons of oxidized iron manganese ore, which was produced entirely in the vicinity of Pioche, is included in the silver ore. This ore contained lead and small quantities of gold and silver and was particularly valuable as flux.

The production of copper ore by 247 operators amounted to 4,945,482 tons and contained 49,419.80 ounces of gold, 327,751 ounces of silver, 122,422,830 pounds of copper, and 20,876 pounds of lead, the value per ton averaging $7.02. The output of lead ores increased from 37,513 tons in 1916 to 66,614 tons in 1917. Lead ore of smelting grade amounted to 31,023 tons. In this smelting ore the oxidized ore, largely carbonates, increased in quantity from 14,428 in 1916 to 26,260 tons in 1917 and averaged $2.38 in gold, 13.17 ounces of silver, 4.48 pounds of copper, 350.85 pounds of lead, and $44.62 in total value per ton. The smelting sulphide ores of lead amounted to 4,763 tons and averaged $1.53 in gold, 22.83 ounces of silver, 6.37 pounds of copper, 680.23 pounds of lead, and $80.58 in total value per ton. Zinc ores of shipping grade decreased from 31,886 tons in 1916 to 18,393 tons in 1917, were all oxidized or carbonate ores, and averaged 642.51 pounds of zinc per ton. Production of copper-lead ores, including some old slag, decreased from 2,846 tons in 1916 to 1,158 tons in 1917, all of which was shipped to smelters. All of the first-class ore, 1,110 tons in quantity, was oxidized or carbonate copper-lead ores, averaging $4.62 in gold, 19.53 ounces in silver, 111.68 pounds of copper, 232.54 pounds of lead, and having a total value per ton of $71.20. There were 27,943 tons of lead-zinc ore produced, the largest part of which, or 27,228 tons, was concentrated into 330 tons of lead concentrate, 1,666 tons of zinc concentrate, and 94 tons of lead-zinc concentrate. Only 715 tons of lead-zinc ore was of shipping grade, and most of this (633 tons) was sulphide.

The output of milling ores was 5,649,565 tons, of which 1,125,255 tons were treated by amalgamation or cyanidation, and the remainder, 4,524,310 tons, by concentration, followed by smelting. The ores and tailings treated by cyanidation—1,057,898 tons of the former and 145,767 tons of the latter—contained an average per ton of $3.87 in gold and 7.66 ounces of silver. The ores amalgamated, 67,357 tons, yielded bullion averaging per ton $6.67 in gold and 0.31 ounce of silver.

Mine production of gold, silver, copper, lead, and zinc in Nevada in 1917.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	91	....	14,153.75	6,278	....	....	....
Dry or siliceous ore	374	1,413,929	268,671.85	10,176,717	69,231	7,193,631	....
Copper ore	247	4,945,482	49,419.80	327,751	122,422,830	20,876	....
Lead ore	256	66,614	3,939.81	556,706	172,265	15,355,354	....
Zinc ore	56	18,393	8.22	2,620	....	43,027	11,817,692
Copper-lead ore	23	1,158	263.74	21,967	127,459	265,113	....
Lead-zinc ore	9	27,943	207.09	177,930	2,919	4,799,927	10,490,176
	......	6,473,519	336,664.26	11,269,969	122,794,704	27,677,928	22,307,868

Ore sold or treated in Nevada in 1917, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Churchill	60,520	14	21	....	32	....	60,587
Clark	24,466	3,115	23,607	17,925	15	20,922	90,050
Douglas	11	10	2	....	....	....	23
Elko	19,609	4,613	2,547	438	176	400	27,783
Esmeralda	257,364	90,838	1,326	30	97	....	349,655
Eureka	706	248	6,079	....	132	....	7,165
Humboldt	94,649	7,518	2,397	....	....	....	104,564
Lander	5,055	17,472	1,228	....	93	....	23,848
Lincoln	124,041	5,287	18,070	....	94	6,595	154,087
Lyon	6,974	322,928	8	....	....	....	329,910
Mineral	246,599	26,879	1,059	....	34	....	274,571
Nye	513,261	43	1,031	....	....	26	514,361
Ormsby	37	....	....	....	....	....	37
Storey	59,805	....	....	....	....	....	59,805
Washoe	434	151	2,235	....	....	....	2,820
White Pine	398	4,466,366	7,004	....	485	....	4,474,253
	[a]1,413,929	4,945,482	66,614	18,393	1,158	27,943	6,473,519
Average value per ton in gold and silver	$9.86	$0.26	$8.10	$0.13	$20.34	$5.40	$2.46

[a] Includes 589,228 tons of gold ore, 17,614 tons of gold and silver ore, and 807,087 tons of silver ore. The last named includes 123,588 tons of oxidized iron ore.

GOLD.

The mine production of gold was valued at $6,959,468 in 1917, a decrease of $1,906,769, as compared with 1916. Nye County is credited with the largest production of gold, amounting to $2,007,234, against $2,505,714 in 1916. Esmeralda County dropped to second place in production with $1,986,001, against $2,684,688 in 1916. Goldfield district, which produced $751,076 less than in 1916, is credited with most of this output. The counties whose gold output was increased were White Pine, Lincoln, Mineral, and Douglas. The largest decreases were in Esmeralda, Nye, and Humbolt counties. Placer gold was produced in greatest quantity in Nye, Lander, and Eureka counties, the value of the total placer gold being $292,584, against $354,313 in 1916. Ore was milled in 1917 by amalgamation in 14 counties and by cyanidation in 12 counties. From these two methods of treatment $5,127,799 in gold was produced from 1,125,255 tons of ore and 145,167 tons of old tailings. The total average gold recovery from ore and tailings milled was $4.03 a ton. The gold extracted by amalgamation averaged $6.67 a ton of ore treated, as against $5.86 a ton in 1916, and by cyanidation it averaged $3.87 a ton of ore and tailings treated, as against $4.44 in 1916. From all concentrates, including siliceous, copper, lead, lead-zinc, and iron sulphide concentrates, 50,465.61 ounces of gold were produced, against 48,459.53 ounces in 1916. The gold in dry or siliceous concentrates was 4,057.75 ounces in 1917, against 13,235.26 ounces in 1916, and was principally from iron sulphide concentrates. The copper concentrates contained 46,030.84 ounces, against 34,482.46 ounces in 1916; the lead concentrates, 327.76 ounces, against 430.81 ounces in 1916; and the zinc concentrates, 49.26 ounces, against 291 ounces in 1916.

Fifteen producers furnished nearly three-fourths of the total gold in 1917. These properties which yielded more than 6,000 ounces each were the Goldfield Consolidated, with 69,632.04 ounces, followed by the Nevada Consolidated Copper mine, at Ely; the Belmont, at Tonopah; Aurora Consolidated, Tonopah Mining, Tonopah Extension; Elko Prince at Midas; Round Mountain Mining Co., in Nye County; Jim Butler, at Tonopah; Florence, at Goldfield; Olympic, in Mineral County; Nevada Wonder, in Churchill County; Union Consolidated, at Virginia City; and West End Consolidated, at Tonopah.

Mine production of gold in Nevada in 1917, in fine ounces.

County.	Placers.	Deep mines.						Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	
Churchill		8,407.81	0.10	0.27		0.17		8,408.35
Clark		8,911.25	980.20	700.21	8.22			10,599.88
Douglas	14.51	23.23		.04				37.78
Elko	29.32	11,768.07	9.72	12.92		4.71		11,824.74
Esmeralda		85,208.90	10,644.74	217.78		1.38		96,072.80
Eureka	133.56	385.39		934.77		11.17		1,464.89
Humboldt	58.34	11,717.02	43.70	112.39				11,931.45
Lander	3,228.84	869.19	165.84	207.73		227.35		4,698.95
Lincoln		919.34	54.62	1,186.75		.26	204.52	2,365.49
Lyon	3.58	2,413.16	23.53	.49				2,440.76
Mineral	20.70	33,656.42	688.95	125.11		.34		34,491.52
Nye	10,600.46	86,331.08	1.29	164.54			2.57	97,099.94
Ormsby		3.68						3.68
Storey		17,457.33						17,457.33
Washoe	5.81	496.81	21.50	1.91				526.03
White Pine	58.63	103.17	36,785.61	274.90		18.36		37,240.67
	14,153.75	[a]268,671.85	49,419.80	3,939.81	8.22	263.74	207.09	336,664.26

[a] Includes 171,815.25 ounces from gold ore, 3,099.45 ounces from gold and silver ore, and 93,757.15 ounces from silver ore.

SILVER.

The mine production of silver in Nevada in 1917 was 11,269,969 ounces, valued at $9,286,454, a decrease of 2,567,556 ounces in quantity but an increase of $181,362 in value, as compared with the output of 1916. Nye County was again the largest producer, with 7,172,642 ounces, against 8,868,267 ounces in 1916; and Churchill County produced 887,765 ounces, against 1,386,524 ounces in 1916.

Milling plants using amalgamation and cyanidation in the extraction of the precious metals produced 9,241,543 ounces of silver, of which 21,191 ounces were recovered by amalgamation and 9,220,352 ounces by cyanidation. Nye County was credited with the largest production of silver by cyanidation—6,840,570 ounces—from ores treated principally in the Tonopah district. In Churchill County, 878,619 ounces of silver were recovered by cyanidation. Concentrates from milling plants yielded 713,459 ounces of silver against 1,107,119 ounces in 1916. Siliceous concentrates contained 309,160 ounces, against 759,370 ounces in 1916; copper concentrates produced 150,950 ounces, against 99,152 ounces in 1916. Lead concentrates contained 191,989 ounces of silver, or an average per ton of 27.89 ounces, against 133,827 ounces, or an average per ton of 26.53 ounces, in 1916. Zinc concentrates contained 61,315 ounces, or an average per ton of 3.36 ounces, and the lead-zinc concentrates contained 45 ounces, or 0.48 ounce per ton.

About 65 per cent of the total silver was produced in 1917 from six mines. The Belmont mines yielded 1,946,757 ounces, followed by the Tonopah Mining, Tonopah Extension, and Jim Butler, all at Tonopah, the Nevada Wonder, in Churchill County, and the West End, at Tonopah.

Mine production of silver in Nevada in 1917, in fine ounces.

County.	Placers.	Deep mines.						Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	
Churchill		885,801	1,243	317		404		887,765
Clark		92,807	10,594	63,581	2,620	145	150,089	319,836
Douglas	2	6	3	88				99
Elko	8	187,128	30,973	42,626		3,295	211	264,241
Esmeralda		81,984	42,611	31,732		891		157,218
Eureka	16	9,769	124	60,754		1,606		72,269
Humboldt	10	816,182	18,973	24,672				859,837
Lander	460	72,056	11,063	36,910		5,581		126,070
Lincoln		321,673	30,416	143,101		1,167	27,042	523,399
Lyon	2	4,163	1,446	151				5,762
Mineral	14	317,920	57,640	31,216		512		407,302
Nye	5,754	7,136,986	1,185	28,129			588	7,172,642
Ormsby		1,662						1,662
Storey		243,072						243,072
Washoe	2	895	1,171	40,153				42,221
White Pine	10	4,613	120,309	53,276		8,366		186,574
	6,278	[a] 10,176,717	327,751	556,706	2,620	21,967	177,930	11,269,969

[a] Includes 534,499 ounces from gold ore, 96,125 ounces from gold and silver ore, and 9,546,093 ounces from silver ore.

COPPER.

Ores mined and treated or shipped in 1917 yielded 122,794,704 pounds of copper, valued at $33,522,954, an increase of 17,677,891 pounds in quantity and of $7,664,218 in value. The Nevada Consolidated mines at Ely, in White Pine County, produced the largest share of the State total, followed by the mines in the Yerington district of Lyon County. White Pine County mines produced 93,786,328 pounds in 1917, against 93,107,945 pounds in 1916; Lyon County mines, 19,397,002 pounds, against 3,491,390 pounds in 1916; Mineral County mines, 3,461,969 pounds, against 2,986,361 pounds; Lander

County mines, 2,480,602 pounds, against 576,493 pounds; and Elko County mines, 887,371 pounds, against 1,771,689 pounds. Concentrates recovered at milling plants contained 86,901,725 pounds of copper, against 88,117,957 pounds in 1916. Of the output in 1917, copper concentrates contained 86,896,898 pounds, against 88,077,620 pounds in 1916. Crude ore shipped to smelters contained 35,565,796 pounds of copper, against 16,764,814 pounds in 1916. The crude copper ores smelted contained 35,228,249 pounds, of which 440,195 pounds were produced from sulphide ores and 34,788,054 pounds from oxidized ores. Lead ores of smelting grade produced 148,039 pounds of copper—30,388 pounds from sulphide ores and 117,651 pounds from oxidized ores. Copper-lead ores shipped, all of which were oxidized, contained 123,969 pounds of copper.

Eight mines produced 95 per cent of the total copper in 1917. The Nevada Consolidated and the Consolidated Copper mines, near Ely, had the greatest output, followed by the Mason Valley, and the Nevada Douglas, in Lyon County; the Copper Canyon, in Lander County; the Wall Street, in Mineral County; and the Goldfield Consolidated in Esmeralda County.

Mine production of copper in Nevada in 1917 in pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Copper-lead ore.	Lead-zinc ore.	Total
Churchill		1,728	80	2,222		4,030
Clark	281	857,835	16,876	3,654		878,646
Douglas		1,986				1,986
Elko	310	852,352	12,773	21,936		887,371
Esmeralda	28,240	705,447	23,104	5,836		762,627
Eureka	315	42,763	20,384	9,379		72,841
Humboldt	250	567,052	308			567,610
Lander	4,968	2,443,834	9,765	22,035		2,480,602
Lincoln	12,397	351,160	67,419	6,302	2,919	440,197
Lyon		19,396,954	48			19,397,002
Mineral	18,030	3,439,358	1,501	3,080		3,461,969
Nye	342	8,406	6,781			15,529
Ormsby	363					363
Washoe	1,110	36,443	50			37,603
White Pine	2,625	93,717,512	13,176	53,015		93,786,328
	[a] 69,231	122,422,830	172,265	127,459	2,919	122,794,704

[a] Includes 29,070 pounds from gold ore, 502 pounds from gold and silver ore, and 39,650 pounds of silver ore.

LEAD.

The mine production of lead in Nevada in 1917 was 27,677,928 pounds, valued at $2,380,302, against 25,637,278 pounds, valued at $1,768,972, in 1916, an increase in 1917 of 2,040,650 pounds in quantity and $611,330 in value. Lincoln County mines continued to have the largest output, 10,714,152 pounds, in 1917, followed by Clark County mines, with 9,373,817 pounds, and by White Pine County mines, with 2,437,908 pounds. More than 25 per cent of the output of lead was derived from concentrates and more than 72 per cent from crude ore shipped directly to smelters. Lead concentrates (carbonates and sulphides) shipped to smelters from the milling plants of the State contained 5,865,304 pounds, against 4,983,673 in 1916, and averaged 42.60 per cent of lead in 1917, against 49.40 per cent in 1916. Zinc concentrates shipped in 1917 contained 1,137,697 pounds of lead and averaged 3.12 per cent. The total crude ore of shipping grade contained 20,068,411 pounds of lead, against 19,189,934 pounds in 1916. The iron-manganese ores, classified under dry or siliceous ores, contained 7,142,452 pounds of lead. Oxidized lead ore shipped to smelters contained 9,213,315 pounds of lead and suphide ore, 3,239,963 pounds, against 5,711,549 pounds and 3,862,549 pounds, respectively, in 1916. Zinc ores shipped produced 43,027 pounds of lead, all of which was from oxidized ores, and copper-lead ores of shipping grade, all oxidized, produced 258,124 pounds of lead. The oxidized lead-zinc ores of smelting grade produced 15,285 pounds of lead, and sulphide lead zinc ores contained 91,492 pounds of lead.

About 41 per cent of the lead was from five mines and the remainder from numerous properties. The leading producer was the Prince Consolidated mine, near Pioche, Lincoln County, followed by the Groom mine, also in Lincoln County, the Union mines, in Eureka County, and the Bullion mine, in the Yellowpine district of Clark county.

Mine production of lead in Nevada in 1917, in pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Churchill			17,145		16,806		33,951
Clark	4,956		4,746,807	43,027	3,428	4,575,599	9,373,817
Douglas			1,226				1,226
Elko		13,305	956,275		33,717	60,848	1,064,145
Esmeralda	23,910		389,806		34,715		448,431
Eureka	1,334		1,736,591		46,008		1,783,933
Humboldt	3,629		507,592				511,221
Lander	11,368		284,102		12,918		308,388
Lincoln	7,142,452	6,710	3,396,277		11,881	156,832	10,714,152
Lyon			2,250				2,250
Mineral	2,607		344,113		11,156		357,876
Nye	764	861	421,752			6,648	430,025
Washoe	393		210,212				210,605
White Pine	2,218		2,341,206		94,484		2,437,908
	[a]7,193,631	20,876	15,355,354	43,027	265,113	4,799,927	27,677,928

[a] Includes 6,469 pounds from gold ore, 2,482 pounds from gold and silver ore, and 7,184,680 pounds from silver ore.

ZINC.

The mine production of recoverable zinc from zinc and lead-zinc ores mined in Nevada in 1917 is calculated at 22,307,868 pounds, valued at $2,275,402, against 32,443,189 pounds, valued at $4,347,387, in 1916. Clark County is credited with the largest part of the output, or 20,660,549 pounds of zinc, most of which came from the Yellowpine district. The remainder of the zinc output was from the Pioche district, in Lincoln County, and from Elko, Esmeralda, and Nye counties. Zinc concentrates amounted to 18,237 tons and averaged 27.94 per cent of zinc. Lead-zinc concentrates contained an average of 37.59 per cent of recoverable zinc, against 25 per cent in 1916. The shipments of crude zinc ore amounted to 18,393 tons, were all oxidized or carbonate ores, and averaged 32.13 per cent of recoverable zinc. The lead-zinc ore, most of which was from one mine at Pioche, averaged 15.97 per cent of recoverable zinc, and was shipped east to an oxide plant.

Nearly 80 per cent of the total zinc was from the ores from four mines, the Yellowpine, Potosi, and Ingomar, all in Clark County, and the Amalgamated Pioche mines, in Lincoln County.

Mine production of recoverable zinc in Nevada in 1917, in pounds.

County.	Zinc ore.	Lead-zinc ore.	Total.
Clark	11,579,611	9,080,938	20,660,549
Elko	222,679	70,675	293,354
Esmeralda	15,402		15,402
Lincoln		1,332,521	1,332,521
Nye		6,042	6,042
	11,817,692	10,490,176	22,307,868

Zinc-producing ores and concentrates from Nevada mines sold in 1917.

Classification.	County.	Quantity.	Average zinc assay of ore and concentrate.[a]
		Short tons.	*Per cent.*
Sulphide lead-zinc ore	Lincoln and Nye	633	17.61
Oxidized zinc ore	Clark, Elko, and Esmeralda	18,393	37.80
Oxidized lead-zinc ore	Clark	82	28.11
Zinc concentrates	Clark and Lincoln	18,237	37.90
Lead-zinc concentrates	Elko	94	44.23
		37,439	35.07

[a] Actual assay content.

MINING INDUSTRY.

The year 1917 was one in which mining operations everywhere faced unusual difficulties, caused to a great extent by war conditions. It was especially trying for new enterprises or companies that were endeavoring to increase the capacity of their plants. The two principal gold and silver camps recorded large decreases in those metals—Goldfield in gold and Tonopah in silver. Discoveries and shipments of silver ore of good grade were made from virgin deep workings on the Comstock lode where pumping lowered the water below the 3,000-foot level. The copper output was increased by the resumption of operations in February at the Mason Valley smelter at Thompson. Several milling plants throughout the State were built or enlarged. The Consolidated Copper Mines Co. completed its 1,000-ton flotation plant at Kimberly, and at Manhattan, Round Mountain, Tuscarora, and Rochester new mills were built or new processes were installed in old mills.

Ores of various kinds were milled at 79 plants, against 84 plants in 1916. Many of these were operated for only short periods each year. Twenty plants used the amalgamation process, against 27 in 1916; 8, both amalgamation and table concentration, against 6 in 1916; 1, amalgamation and cyanidation, against 3 in 1916; and 3 used amalgamation, table concentration, and cyanidation. Eighteen plants, against 15 in 1916, used concentration, of which four were equipped with the oil flotation process in conjunction with tables, and 2 were equipped for oil flotation only. Twenty-five straight cyanidation mills were operated in 1917, against 31 in 1916; and 3 mills used cyanidation and concentration, against 2 in 1916. At one plant, in Lyon County, experimental work with the leaching process was done.

During 1917 there were 839 pounds of quicksilver consumed at amalgamation mills. At cyanide mills, 130 pounds of potassium cyanide and 1,925,038 pounds of sodium cyanide were used, or 1,925,168 pounds of both. There was a consumption of 0.02 pound of mercury per ounce of gold and silver bullion produced and of 0.012 pound of mercury per ton of ore treated; the consumption of cyanide was 0.20 pound per ounce of gold and silver bullion produced and 1.60 pounds per ton of ore and tailings treated.

The total value of bullion recovered from ore and tailings was $12,742,830, against $14,295,539 in 1916.

Gold and silver produced from Nevada mills in 1917.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Churchill	60,493	5.35	2	8,261.16	878,619	$894,868
Clark	[a] 14,415	1,636.63	9,230	[b] 6,101.69	[b] 69,615	224,933
Douglas	10	19.83	2	....	....	412
Elko	19,468	166.32	99	11,402.85	179,991	387,550
Esmeralda	168,698	1,987.08	639	[c] 70,625.06	[c] 51,519	1,544,004
Eureka	450	116.04	39	....	....	2,431
Humboldt	[d] 93,677	3,841.15	3,419	[e] 7,351.89	[e] 782,569	879,035
Lander	[f] 2,801	91.25	88	470.98	1,394	12,843
Lincoln	453	....	....	226.75	67	4,742
Lyon	2,353	1,950.27	1,424	[g] 441.42	[g] 2,736	52,869
Mineral	[h] 202,748	275.48	125	[i] 32,704.52	[i] 188,780	837,415
Nye	[j] 509,692	8,999.66	4,131	[k] 75,313.46	[k] 6,840,570	7,382,941
Storey	[l] 49,640	2,170.60	1,755	[m] 13,412.04	[m] 224,458	508,521
Washoe	341	469.15	235	....	....	9,892
White Pine	16	11.71	3	4.96	31	374
	1,125,255	21,740.52	21,191	226,316.78	9,220,352	12,742,830

[a] Also yielded 111 tons of concentrates.
[b] Includes bullion from 10,000 tons of old tailings.
[c] Includes bullion from 81,885 tons of old tailings.
[d] Also yielded 38 tons of concentrates.
[e] Includes bullion from 310 tons of old tailings.
[f] Also yielded 14 tons of concentrates.
[g] Includes bullion from 4,620 tons of old tailings.
[h] Also yielded 2 tons of concentrates.
[i] Includes bullion from 37,217 tons of old tailings.
[j] Also yielded 851 tons of concentrates.
[k] Includes bullion from 1,650 tons of old tailings.
[l] Also yielded 170 tons of concentrates.
[m] Includes bullion from 10,085 tons of old tailings.

Mills equipped for the concentration of low-grade ore treated 4,524,310 tons, or nearly 70 per cent of the total ore sold or treated. The concentrates aggregated 627,416 tons and contained $1,043,217 in gold, 713,459 ounces of silver, 86,901,725 pounds of copper, 7,019,812 pounds of lead, and 10,261,726 pounds of recoverable zinc, valued in all at $27,005,678, or a total average value per ton of $43.04.

Mine production of gold, silver, copper, lead, and zinc from Nevada concentrates in 1917.

By counties.

County.	Ore to concentrating mills.	Concentrates.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value of concentrates.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Churchill	....	54	52.53	6,818	....	....	....	$6,704
Clark	38,748	21,600	781.12	179,082	281	5,872,856	9,042,002	1,591,137
Elko	400	133	....	211	....	60,848	70,675	12,616
Esmeralda	88,600	5,943	10,479.97	40,024	513,369	....	....	389,770
Eureka	40	17	....	106	....	4,082	....	438
Humboldt	125	51	245.18	4,901	....	1,626	....	9,246
Lander	1,658	158	41.10	11,792	945	59,859	....	15,973
Lincoln	5,988	2,926	340.95	34,214	2,984	499,131	1,149,049	196,183
Mineral	98	19	4.63	146	3,404	1,745	....	1,295
Nye	1,360	885	1,748.06	269,257	342	....	....	258,097
Storey	....	170	1,201.49	7,027	....	....	....	30,627
Washoe	2,066	298	1.83	40,087	50	198,878	....	50,188
White Pine	4,385,232	595,162	35,568.75	119,794	86,380,350	320,787	....	24,443,404
	4,524,310	627,416,	50,465.61	713,459	86,901,725	7,019,812	10,261,726	27,005,678

By kinds of concentrates.

Dry or siliceous	1,344	4,057.75	309,160	1,787	6,323	....	$339,661
Copper	600,857	46,030.84	150,950	86,896,898	....	....	24,798,778
Lead	6,884	327.76	191,989	3,040	5,865,304	....	670,221
Zinc	18,237	49.26	61,315	....	1,137,697	10,191,051	1,188,870
Lead-zinc	94	....	45	....	10,488	70,675	8,148

All the higher grade ores were shipped crude to the smelters, the copper ores in greatest quantity and in value. There were 658,447 tons of ore smelted in 1917, as compared with 371,053 tons in 1916. The output of smelting ores by counties follows:

Mine production of gold, silver, copper, lead, and zinc from Nevada crude ore shipped to smelters in 1917.

By counties.

County.	Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Churchill	94	89.31	2,326	4,030	33,951	....	$7,782
Clark	26,444	1,702.88	60,770	806,765	3,500,961	11,618,547	1,791,697
Douglas	13	3.44	95	1,986	1,226	....	796
Elko	7,915	226.25	83,932	887,371	1,003,297	222,679	425,086
Esmeralda	10,472	12,980.69	65,036	207,003	448,431	15,402	418,573
Eureka	5,861	934.99	66,757	57,997	1,702,115	....	236,531
Humboldt	5,935	412.74	59,177	434,110	120,412	....	186,161
Lander	19,389	866.78	112,336	2,479,657	248,529	....	808,802
Lincoln	137,090	1,730.04	483,953	427,946	10,099,224	183,472	1,438,616
Lyon	322,371	45.49	1,600	19,350,592	2,250	....	5,285,165
Mineral	32,154	1,398.80	171,632	3,458,565	356,131	....	1,145,157
Nye	1,605	407.59	51,495	15,187	430,025	6,042	92,602
Ormsby	37	3.68	1,662	363	....	....	1,544
Storey	80	673.20	9,832	....	....	....	22,018
Washoe	263	49.24	1,897	37,553	11,727	....	13,841
White Pine	88,724	1,581.13	66,446	7,396,671	2,110,132	....	2,288,199
	658,447	23,105.25	1,238,946	35,565,796	20,068,411	12,046,142	14,162,570

By kinds of ore.

Dry or siliceous	137,700	15,952.72	576,337	65,539	7,186,329	....	$1,440,590
Copper	469,506	3,495.27	172,435	35,228,249	20,876	....	9,833,448
Lead	31,023	3,370.52	454,566	148,039	12,453,278	....	1,555,634
Zinc	18,393	8.25	2,620	....	43,027	11,817,692	1,211,433
Copper-lead	1,110	248.24	21,680	123,969	258,124	....	79,037
Lead-zinc	715	30.25	11,308	....	106,777	228,450	42,428

PRODUCTION BY COUNTIES.

The following tables show the State output, by counties, in 1917, the production of each metal, and the total value; also the production of ore, the average value per ton by counties, in 1916 and 1917; and the statistics of placer mines. The tables are followed by a review of the mining industry for each county and each producing mining district.

Mine production of gold, silver, copper, lead, and zinc in Nevada in 1917.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.	Quantity.	Value.
	Quantity.	Value.	Quantity.	Value.			
	Fine ounces.		*Fine ounces.*			*Fine ounces.*	
Churchill	....	....	8,408.35	$173,816	$173,816	887,765	$731,518
Clark	....	....	10,599.88	219,119	219,119	319,836	263,545
Douglas	14.51	$300	23.27	481	781	99	81
Elko	29.32	606	11,795.42	243,833	244,439	264,241	217,734
Esmeralda	....	....	96,072.80	1,986,001	1,986,001	157,218	129,548
Eureka	133.56	2,761	1,331.33	27,521	30,282	72,269	59,550
Humboldt	58.34	1,206	11,873.11	245,439	246,645	859,837	708,506
Lander	3,228.84	66,746	1,470.11	30,390	97,136	126,070	103,882
Lincoln	....	....	2,365.49	48,899	48,899	523,399	431,281
Lyon	3.58	74	2,437.18	50,381	50,455	5,762	4,748
Mineral	20.70	428	34,470.82	712,575	713,003	407,302	335,617
Nye	10,600.46	219,131	86,499.48	1,788,103	2,007,234	7,172,642	5,910,257
Ormsby	....	....	3.68	76	76	1,662	1,369
Storey	....	....	17,457.33	360,875	360,875	243,072	200,291
Washoe	5.81	120	520.22	10,754	10,874	42,221	34,790
White Pine	58.63	1,212	37,182.04	768,621	769,833	186,574	153,737
	14,153.75	292,584	322,510.51	6,666,884	6,959,468	11,269,969	9,296,454

Mine production of gold, silver, copper, lead, and zinc in Nevada in 1917.

County.	Copper.		Lead.		Recoverable zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Churchill	4,030	$1,100	33,951	$2,920	....	....	$909,354
Clark	878,646	239,870	9,373,817	806,148	20,660,549	$2,107,376	3,636,058
Douglas	1,986	542	1,226	106	....	....	1,510
Elko	887,371	242,252	1,064,145	91,517	293,354	29,922	825,864
Esmeralda	762,627	208,197	448,431	38,565	15,402	1,571	2,363,882
Eureka	72,841	19,886	1,783,933	153,418	....	....	263,136
Humboldt	567,610	154,958	511,221	43,965	....	....	1,154,074
Lander	2,480,602	677,204	308,388	26,521	....	....	904,743
Lincoln	440,197	120,174	10,714,152	921,417	1,332,521	135,917	1,657,688
Lyon	19,397,002	5,295,382	2,250	194	....	....	5,350,779
Mineral	3,461,969	945,117	357,876	30,777	....	....	2,024,514
Nye	15,529	4,239	430,025	36,982	6,042	616	7,959,328
Ormsby	363	99	....	....	....	....	1,544
Storey	....	....	....	....	....	....	561,166
Washoe	37,603	10,266	210,605	18,112	....	....	74,042
White Pine	93,786,328	25,603,668	2,437,908	209,660	....	....	26,736,898
	122,794,704	33,522,954	27,677,928	2,380,302	22,307,868	2,275,402	54,424,580

Production from deep mines in Nevada in 1916 and 1917.

County.	Ore sold or treated.		Number of deep mines producing.		Average value per ton.[a]		Average value per ton in gold and silver.[a]	
	1917	Increase or decrease.	1916	1917	1916	1917	1916	1917
	Short tons.	*Short tons.*						
Churchill	60,587	− 50,356	20	13	$10.81	$15.01	$10.78	$14.94
Clark	90,050	− 13,324	85	106	50.64	40.38	5.56	5.36
Douglas	23	− 61	3	4	17.82	52.52	.31	24.35
Elko	27,783	− 12.946	75	77	26.99	29.70	11.25	16.61
Esmeralda	349,655	− 39,696	59	61	8.14	6.76	7.18	6.05
Eureka	7,165	− 14,917	30	40	18.86	36.34	9.01	12.15
Humboldt	104,564	− 5,119	84	100	9.13	11.03	8.78	9.12
Lander	23,848	+ 7,749	30	47	21.22	35.12	11.55	5.61
Lincoln	154,087	− 8,066	23	23	9.77	10.76	2.48	3.12
Lyon	329,910	+298,488	44	64	30.61	16.22	3.28	.17
Mineral	274,571	+ 8,388	98	129	6.56	7.37	3.73	3.82
Nye	514,361	− 50,089	73	79	14.47	15.04	14.45	14.96
Ormsby	37	− 70	3	1	6.46	41.73	6.15	39.05
Storey	59.805	− 3,382	24	33	10.64	9.38	10.62	9.38
Washoe	2,820	− 2,241	28	31	25.68	26.21	14.19	16.15
White Pine	4,474,253	+417,996	40	44	5.88	5.98	.21	.21
	6,473,519	+532,354	714	852	8.35	8.36	2.96	2.46

[a] Value per ton, placer product excluded.

Production from placer mines in Nevada in 1916 and 1917.

County.	1916					1917				
	Mines.		Gold.	Silver.	Total value.	Mines.		Gold.	Silver.	Total value.
	Hydraulic.	Drift.				Hydraulic.	Drift.			
				Fine ounces.					*Fine ounces.*	
Douglas	2	....	$88	....	$88	1	....	$300	2	$302
Elko	1	....	48	1	49	3	....	606	8	613
Eureka	6	....	10,373	44	10,402	5	....	2,761	16	2,774
Humboldt	6	5	7,174	90	7,233	3	1	1,206	10	1,214
Lander	1	10	153,698	1,050	154,389	27	6	66,746	460	67,125
Lyon	3	....	2,328	40	2,354	....	1	74	2	76
Mineral	2	1	743	11	750	3	1	428	14	43[illegible]
Nye	24	3	179,165	4,501	182,127	24	11	219,131	5,754	223,872
Washoe	....	....	....	....	....	2	....	120	2	122
White Pine	1	....	696	7	701	3	....	1,212	10	1,220
	46	19	354,313	5,744	358,093	71	20	292,584	6,278	297,757

CHURCHILL COUNTY.

There were 60,587 tons of ore mined in Churchill County in 1917 by 13 producers, against an output of 110,943 tons mined by 20 producers in 1916. The total average value per ton increased from $10.81 in 1916 to $15.01 in 1917. Only a small quantity of ore containing copper and lead was shipped. The larger part of the output was of milling grade and yielded gold and silver bullion at cyanidation plants. Some concentrate from a gold and silver mill was shipped directly to the smelters, as was also 94 tons of crude ore containing gold and silver, with some copper and lead.

Eagleville district.—The Golden Extension property was reported as a producer of siliceous gold ore carrying a little silver.

Eastgate district.—Several small prospects produced altogether 49 tons of ore, yielding principally lead with some gold and silver and a little copper.

Fairview district.—The Nevada Hills property, after steadily producing for more than 9 years, was given its final clean-up, after which it was closed. Some gold and silver bullion and concentrate were shipped. According to the annual report of the company[1] 4,683 tons of ore were milled and cyanided, and yielded silver bullion valued at $18,811.93. From the treasury $319,706 was paid out in dividends during 1917.[1] The company report contains the following:

> Your company operated its property and mill during the months of January and February, 1917, at which time a cold wave struck the State causing the lowest temperature that had visited Nevada in a number of years. The water supply line became frozen and necessitated the shutting down of operations until the month of May. In that month operations were resumed, but despite the increased price of silver it was found that it was impossible to operate the property at a profit. The ore reserves had become so depleted and the mineral content so low that the recovery would not meet the expenses. Therefore in the month of June the property was permanently shut down and preparation made for disposal of the plant as junk and second-hand material.

Jessup district.—A small lot of silver ore, containing a little gold, was shipped from the district in 1917.

Wonder district.—The principal production of the district continues to come from the Nevada Wonder mine,[2] which produced 55,800 tons of ore in 1917, averaging 0.141 ounce of gold and 16.65 ounces of silver per ton. This ore was treated by the cyanide process and yielded bullion containing 7,512 ounces of gold and 816,852 ounces of silver, valued at $822,940, representing a recovery of 95.32 per cent of the gold content and 87.9 per cent of the silver. The silver saving in 1916 was 91.9 per cent, and its decreased recovery in 1917 is discussed in the company's annual report as follows:

> The low recovery of silver contents was caused by a change from the readily soluble silver minerals in the ore to the more complex and less soluble silver minerals found at depth in the mine. * * * The only remedy for this was the installation of concentrators for removing the less soluble sulphides. It was decided to install four Senn concentrators, and the concentrator unit will be ready for service about January 15, 1918, after which date it is thought the silver recovery will approach the former excellent record.

The direct mining cost per ton of ore treated was $4.46 per ton in 1916, against $5.41 per ton in 1917. The indirect costs were 83 cents and 97 cents per ton, respectively. The following table gives the combined mining and milling costs and the profits per ton of the ore mined and milled, compared with those of the three previous years:

	1914	1915	1916	1917
Total mining costs per ton of ore, including transportation	$4.70	$4.19	$5.33	$6.43
Total milling costs per ton of ore	3.37	2.81	3.31	4.12
Marketing costs per ton of ore	.28	.27	.26	.23
Total costs per ton	8.35	7.27	8.90	10.78
Average value per ton of ore	15.52	13.97	15.40	16.55
Loss in tailing per ton of ore	1.06	.82	1.13	1.80
Recovery per ton	14.46	13.15	14.27	14.75
Less total costs per ton	8.35	7.27	8.90	10.78
Profit per ton of ore mined and milled	6.11	5.88	5.37	3.97

---

[1] Nevada Hills Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

[2] Nevada Wonder Mining Co. Eleventh Ann. Rept., for year ending Dec. 31, 1917.

Altogether the dividends paid Nevada Wonder stockholders since May 20, 1913, amount to $1,196,886.95, of which $281,681.80 was paid in 1917.

CLARK COUNTY.

Mine production in Clark County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	85	103,374	$308,272	404,788	573,088	8,405,796	29,400,537	$5,235,275
1917	106	90,050	219,119	319,836	878,646	9,373,817	20,660,549	3,636,058
Increase or decrease, 1917		−13,324	−89,153	−84,952	+305,558	+968,021	−8,739,988	−1,599,217

The production in 1917 of 90,050 tons of ore by 106 producers was 13,324 tons less than was produced by 85 mines in 1916. The total average value per ton decreased from $50.64 in 1916 to $40.38 in 1917, and the gold and silver value per ton in this ore decreased from $5.56 to $5.36. Of the total ore, 26,444 tons were shipped directly to the smelters and produced $35,201 in gold, 60,770 ounces of silver, 806,765 pounds of copper, 3,500,961 pounds of lead, and 11,618,547 pounds of recoverable zinc, valued at $1,791,697, or an average value per ton of $67.74. There were 37,748 tons of ore treated by concentration or separation processes, which produced lead concentrates, zinc concentrates, and a small quantity of lead-zinc and copper-lead concentrates. The 21,600 tons of concentrates produced had a metal content of $16,147 in gold, 179,082 ounces of silver, 281 pounds of copper, 5,872,856 pounds of lead, and 9,042,002 pounds of recoverable zinc, valued in all at $1,591,137, or an average value per ton of $73.66. At gold and silver mills, 14,415 tons of ore were treated and produced $159,965 in gold and 78,845 ounces of silver.

Crescent district.—Very little activity was reported in the district, and only one small lot of lead ore was shipped.

Eldorado Canyon district.—Seven operators reported 12,689 tons, yielding $137,079 in gold, 90,618 ounces of silver, 281 pounds of copper, and 4,956 pounds of lead, valued in all at $212,251, or an average value per ton of $16.73. The bulk of this ore was treated in gold and silver mills and yielded some gold and silver concentrate containing a little lead and copper. There were only 6 tons of crude gold and silver ore shipped from the district. The principal producer was the Techatticup mine, on which a 50-ton cyanide plant was operated. The ore produced is both oxidized and sulphide with a siliceous gangue. The Rand mine, which yielded bullion from treatment by amalgamation and a little lead concentrate, was the next in importance as a producer of milling ore. The Lombard, Lucky Jim, Flagstaff, and Carnation mines were also producers.

Gas Peak district.—From the June Bug property some oxidized zinc ore was shipped during three months' operation of the property in 1917.

Gold Butte district.—The Lincoln property yielded copper ore of shipping grade, and some oxidized zinc ore was shipped from the Black Jack claim.

Las Vegas district.—The Johnnie Stump prospect, situated about 8 miles west of Las Vegas, was a producer of a small quantity of oxidized copper ore.

Searchlight district.—There were 14 producers who reported 12,866 tons of ore, containing $71,213 in gold, 9,073 ounces of silver, 98,923 pounds of copper, and 59,453 pounds of lead, valued in all at $110,808, or an average value per ton of $8.61. More than half of the ore was of milling grade, yielding bullion in gold and silver mills, and 1,134 tons were shipped directly to the smelter and contained 1,526.64 ounces of gold, 7,101 ounces of silver, and all the copper and lead. There were also about 10,000 tons of old tailings re-treated by the cyanidation process, yielding some gold and silver bullion. The Quartette property, worked largely by lessees, was the principal producer of gold and silver. Some of the ore containing copper was shipped directly to the smelter. The Duplex mine was also a producer of gold and silver bullion, and also yielded some oxidized lead ores containing copper. Other producers were the Chief of the Hills, Cyrus Noble, Spokane, and Parallel properties.

Yellow Pine district.—Seventy-nine producers reported the production of 64,260 tons of ore, containing $10,656 in gold, 219,789 ounces of silver, 764,733 pounds of copper, 9,298,706 pounds of lead, and 20,535,768 pounds of recoverable zinc, valued in all at $3,294,870, or an average value per ton of $51.27. More than half of the ore, or 38,748 tons, was milled and yielded 21,489 tons of concentrate containing 166,674 ounces of silver, 5,867,900 pounds of lead, and 9,042,002 pounds of recoverable zinc. The ore shipped directly to the smelters, some of it through the Jean sampling works, amounted to 25,069 tons, containing 137.94 ounces of gold, 51,976 ounces of silver, 693,133 pounds of copper, 3,430,806 pounds of lead, and 11,493,766 pounds of recoverable zinc. The principal producer was the Yellow Pine mine, and other producers of more than 1,000 tons of ore were the Bullion, Anchor, Ingomar, Campbell Estate, Potosi, and Sultan. The ore sampling company, which completed a plant at Jean in April, was preparing to close and dismantle it at the end of the year, having had very little profitable business. In addition to the producing properties mentioned, the output of the Boss mine was an important one. The ore shipped to the Palau metal works at Los Angeles was reported to contain 49 ounces of gold and 85 ounces of combined platinum and palladium. This ore is the plumbojarosite, which, according to Knopf,[1] carries the rare metals. The experimental mill at the Boss mine was not successfully operated, so after June nearly all of the ore was shipped to various smelters, the low-grade copper ore containing small quantities of the rare metals going to Garfield, Utah, and Irvington, N. J. The total output of the Boss mine[2] was 1,098.7 tons of ore, of which 359.91 tons averaged per ton 0.8364 ounce of gold, 2.61 ounces of silver, 0.2573 ounce of platinum, and 0.9842 ounce of palladium. In addition to this, the ore contained 8.5 per cent of copper, which, with all the other metals, yielded the company $42,193.77. The straight copper ore, 621.17 tons, contained 9.74 per cent of copper and also contained an average per ton of 0.0925 ounce of gold, 2.083 ounces of silver, and 0.075 ounce of combined platinum and palladium. This ore netted the company $20,645.74, making a total of $62,839.51 received from the smelters in 1917.

---

[1] Knopf, Adolph, A gold-platinum-palladium lode in southern Nevada: U. S. Geol. Survey Bull. 620, pp. 1–18, 1916.

[2] Boss Gold Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

At the Yellow Pine mine[1] 20,047.24 tons of ore were mined at an average cost of $4.516 per ton. Of this quantity, 464.83 tons were shipped as crude ore and 19,582.4 tons were milled. The lowest depth yet attained in the mine is the 900-foot level, but the most important ore developments of 1917 occurred at the north end of the mine in the vicinity of the 700-foot level, where a very large ore body of unusually good grade was encountered, evidently an extension of the ore zone above, faulted to the hanging wall. The ore was developed for a distance of 250 feet along the strike and 120 feet on the dip, with an average thickness of about 30 feet and the exact limits undetermined. Assays taken of the ore show 30 per cent zinc and 18 per cent lead, and also 12 ounces of silver per ton. Concerning the products from the mill, the company report gives the following:

> A marked difference in ore market conditions now existing has resulted in the determination of your directors to make a radical change in our future operations. Our contract for zinc ore products, which has existed the past five years, expires on February 1, 1918, and the present market for the class of ore we have been producing is such that it has been deemed advisable to discontinue milling, and hereafter to ship all ore in the crude state.
>
> In consequence, our milling plant will be closed on February 1, and a large proportion of our product will be shipped to oxide plants as a mixed lead-zinc ore. It is our intention to improve sorting facilities at the mine, so that a considerable portion of the crude lead ore and crude zinc ore may be sorted out and shipped separately. For the balance of the product, we have recently entered into a favorable one-year contract covering 14,000 to 18,000 tons of mixed ore annually. During the first six months of the contract, the price has been made irrespective of metal markets and thereafter dependent upon the rise and fall of the lead and zinc markets. * * *
>
> No attempt has been made to estimate accurately available tonnage in the mine, as the newer ore bodies are not sufficiently blocked, but it may be stated safely that ample tonnage for the next twelve months is absolutely assured. * * *
>
> During 1917, the mill operated 5,502.5 hours or a total of 344 sixteen-hour days, treating a total of 19.976 tons, or an average of 3.63 tons per hour. The average cost per ton was $1.95.
>
> From a mill head averaging 14.85 per cent lead, 29.1 per cent zinc, and 7.55 ounces silver per ton, there were produced 3,157.9 tons of lead concentrate, averaging 52.6 per cent lead, 13.6 per cent zinc, and 29.8 ounces silver per ton; 12,904.9 tons of zinc concentrate, averaging 5.15 per cent lead, 32.0 per cent zinc, and 3.18 ounces silver per ton; and 3,512.7 tons of slime, averaging 6.9 per cent lead, 32.2 per cent zinc, and 3.53 ounces silver per ton. Waste sorted from the belt amounted to 393.6 tons. * * *

---

[1] Yellow Pine Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

Product from Yellow Pine mine in 1917.

Class of ore.	Quantity.	Lead.	Zinc.	Silver.	Net value.	Total value.
	Short tons.	*Per cent.*	*Per cent.*	*Ounces.*	*Per ton.*	
Lead concentrate	3,157.9470	52.60	13.60	29.80	$80.11	$253,999.89
Zinc con centrate	12,904.9565	5.15	32.00	3.18	28.72	306,053.75
Zinc slimes	3,512.6930	6.90	32.20	3.53	23.30	81,853.13
Crude zinc ore	411.1775	3.50	37.90	1.54	32.71	13,442.57
Crude lead ore	2.6800	63.10	5.65	21.60	109.16	292.56
Crude mixed ore	50.9730	16.00	27.20	11.50	24.76	1,263.42
	20,040.4270	....	....	....	....	656,905.32

Dividends disbursed in 1917 amounted to $360,000.

DOUGLAS COUNTY.

Five producers reported the output of 23 tons of ore, of which 13 tons were shipped directly to the smelter and 10 tons treated at gold and silver mills. The total value per ton of the ore was $52.52 and the gold and silver value was $24.35. The placer production amounted to $300 in gold.

Gardnerville district.—A small quantity of ore containing gold was mined from the Emerald property and a small lot of similar ore came from the Pine Nut Consolidated mine.

Mount Siegel district.—A small gold production, taken out in doing assessment work on the Ancient Gold placer, was reported.

Red Canyon district.—The Winters property, near Gardnerville, produced a little lead ore in 1917.

ELKO COUNTY.

Mine production in Elko County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	76	40,729	$282,154	268,156	1,771,689	1,098,911	963,438	$1,099,363
1917	80	27,783	244,439	264,241	887,371	1,064,145	293,354	825,864
Decrease, 1917	....	12,946	37,715	3,915	884,318	34,766	670,084	273,499

[a] Includes placer production.

The output of ore reported by 77 deep-mine producers was 27,783 tons in 1917, which was 12,946 tons less than was produced by 75 operators in 1916. The total average value per ton of the ore increased from $26.99 in 1916 to $29.70 in 1917, and the gold and silver value per ton from $11.25 to $16.61. A large part of the ore (19,468 tons) was treated at gold and silver mills, and yielded bullion containing $239,156 in gold and 180,090 ounces of silver. A small quantity of lead concentrate and lead-zinc concentrate was produced at one of the mills. The ore shipped was 7,915 tons, containing gold, silver, copper, lead, and zinc, valued at $425,086, or an average value per ton of $53.71. Placer operators reported the production of $606 in gold and 8 ounces of silver.

Aura district.—Some silver ore containing a little gold from the Big Four property, operated by a lessee, was the only production reported in the district.

Centennial district.—Small test lots of ore came from the Gold Dollar and Red Cloud properties in 1917.

Contact district.—All the ore produced in the district, reported by eight operators, was of shipping grade, and amounted to 253 tons, containing 1.88 ounces of gold, 746 ounces of silver, 65,665 pounds of copper, and 5,215 pounds of lead. Production was reported from the Bellevue, Valley View, Champ Clark, Bonanza, Blue Bird, and Hanks copper properties.

Delkar district.—A lessee operated the Copper Belt property and shipped to the smelters an oxidized copper ore.

Ferber district.—The Salt Lake group was operated by the Ferber Copper Co. There were two kinds of ore produced, oxidized copper ore and lead ore. The ore was hauled to Erickson on the Deep Creek branch line of the Western Pacific Railroad operated from Wendover to Gold Hill, Utah.

Ferguson district.—The Bullion group and two other properties were producers of copper and lead oxidized ores.

Gold Circle district.—Sixteen producers reported the production of 19,523 tons of ore containing $242,198 in gold and 182,844 ounces of silver, valued in all at $392,861, or an average value per ton of $20.12. Only 102 tons of gold and silver ore were shipped from the district directly to smelters. The remainder of the production was milled, yielding gold and silver bullion by cyanidation. The principal producer was the Elko Prince property, which is opened by a 700-foot adit and a 450-foot shaft. The cyanide mill on the property has a capacity of 50 tons. There was also a 2-stamp amalgamation mill operated in the district which treated some ore from the Esperanza and Queen properties. The Rand & Masey, Missing Link, June Bell, Lucky Boy, and Rex properties were also producers.

An interesting paper[1] recently published describes the Elko Prince mine and mill and gives a brief history of the district as follows:

> The Elko Prince mine is in the Gold Circle district, Nevada, about 1½ miles (2.4 kilometers) from the town of Midas, 55 miles (88.5 kilometers) west of Battle Mountain, and 50 miles (80.5 kilometers) northeast of Golconda. The district is described by Emmons in United States Geological Survey Bulletin 408, 1910. Little was said of the Elko Prince, however, as only a small amount of work had then been completed.
>
> The geological structure of the region is simple. The oldest exposed formation, covering most of the area, is rhyolite, which has a light-colored devitrified groundmass inclosing phenocrysts of feldspar, quartz, and magnetite. It has been somewhat weathered and partially stained with oxide of iron. There are several outcrops of andesite which cut the rhyolite. The ore deposits occur as fissure veins, replacement veins, and sheeted zones. The Elko Prince vein is of the first type. The rhyolite near the veins is silicified, stained with oxide of iron, and, at some localities, replaced by ore, or is so permeated by metals as to be classed as ore. The vein filling consists chiefly of quartz, and the values consist entirely of gold and silver. Part of the gold exists as the native metal and part is associated with pyrite. Silver occurs free and as argentite in

---

[1] Dorr, J. V. N., and Dougan, L. D., Elko Prince mine and mill: Am. Inst. Min. Eng. Bull. 140, pp. 1235–1254, August, 1918.

banded streaks through the vein. These veins trend in a northwesterly direction, with dips varying from 65° to vertical.

Gold was discovered in the district in the fall of 1907, and a characteristic rush followed. The town of Midas was laid out and shortly had 2,000 inhabitants. Several small mills were built, one of which, the Rex, ran several years. After the first excitement, the people drifted away rapidly, and at present only about 150 remain. The Elko Prince claims were located in 1907 by Paul Ehlers, a prospector, and 10 claims were patented in 1913 after considerable development work had been done. * * *

The outcrop of the Prince vein is insignificant, only a narrow seam of low-grade quartz, or an obscure fissure containing no quartz or metals. The first work on the property was a 60-foot shaft sunk on the cropping. A narrow seam of mineralized quartz was followed, but nothing of importance was found; then a 240-foot drift on the vein gave similar results. Later, a 700-foot crosscut reached the vein 270 feet below surface, and cut an ore shoot almost in the center. Subsequent work developed a vein having an average width of 14 to 15 inches, a total tonnage of 30,000, and a gross value of approximately $1,000,000, the limits of the ore body being quite well defined.

In June, 1915, the Elko Prince Mining Co. made an agreement with the Dorr Co., whereby the latter was to design, finance, and build a cyanide mill of at least 40 tons daily capacity, furnish additional mine equipment, and operate the property until certain financial results had been attained. Milling was begun in November, 1915, and the original terms were completed in June, 1917, but the Dorr Co., operating through the Elko Prince Leasing Co., has continued in charge of the property to the present time.

The Prince vein has a uniform northwest-southeast strike and a dip varying from vertical to 85° NE. One horizontal fault of a few feet occurs in the 1,400 feet of development on the property, and a second, of much greater extent, probably occurs just beyond the south end line.

The vein filling is hard but brittle quartz, with a very small amount of sulphides. Partial oxidation extends from the surface to the deepest openings. Manganese in oxidized form is found in spots. No enrichments due to leaching and redeposition have been observed, except as to a small portion of silver. The gold is mainly free but very fine; about 50 per cent can be amalgamated. Thin flakes of native silver are found in the footwall and penetrate its seams in places to a depth of an inch. The silver exists chiefly as argentite and polybasite, giving the quartz the characteristic banded appearance that usually accompanies the presence of these minerals.

A characteristic analysis of the ore is:

	Per cent.		Per cent.		Per cent.
SiO_2	85.0	S	0.1	Ignition loss	2.0
Al_2O_3	2.0	As	.1	Cu	.0
Fe	3.0	Sb	.1	Au (ounce per ton)	.7
Cao	4.0	Mn	Trace.	Ag (ounces per ton)	10.0

A second vein, the June Bell, is parallel to the Prince, and lies a short distance to the west. It is of the same type but much smaller, and gives promise of producing but little metal. * * * The financial arrangements allowed the mill to be designed so that when the ore body already developed had been worked out and the plant scrapped, the greatest net profit would have been made. The treatment of 50 tons of sorted ore daily promised a life of about three and one-half years, with the chance of an extension by finding other ore bodies or obtaining custom ore.

Labor was scarce in the district, and, although there was no labor union, the Tonopah scale of $4 minimum for eight hours had been paid.

Redhouse, on the Western Pacific, the nearest freight station, is 34 miles away, and hauling by wagon costs from $13.50 to $15 per ton. The road from Redhouse to Midas is a good desert road, with a large increase in grade in the last 5 miles. The chance of heavy snow at the upper end in winter, and the certainty of very heavy hauling in spring, made it essential to stock up by December to run until May. Hauling by team has proved more satisfactory than by motor truck. Oil storage of 22,000 gallons was provided at the mill. No electric power was available. * * *

The treatment follows the standardized lines of ball-mill crushing and fine grinding with countercurrent decantation and zinc-dust precipitation. * * *

Water is pumped from a well below the town of Midas, a distance of 11,000 feet with a lift of 700 feet. A crude-oil engine was first installed, but it required so much attention that it was replaced with a 10-horsepower motor; the water pipe is used as the return electrical circuit. * * *

As electric power was not available, and coal was too expensive, an oil engine was the only motive power considered. A 150-horsepower Fairbanks-Morse engine on the property might have furnished a large part of the power needed; but, as fuel oil cost 12 cents per gallon delivered, and the rated consumption of the engine was double that of a Diesel, the initial saving would have been lost in operating. * * *

The following figures, representing costs of construction in 1915, are, unfortunately, only of historical value today:

Mill, complete (including power plant)	$67,509.06
Refinery	2,560.11
Oil storage and wagons	2,162.05
Office, assay office, and other buildings and equipment	8,071.48
Total surface expenditures, except water line already installed	80,302.70

The total cost of the mill machinery and tanks, at shipping point, was $33,647.18, checking rather closely the common estimate that a mill erected would cost double the cost of the machinery.

The lumber, 205 M. costing $48 per M. at the site, cost $20.42 per M. to erect; machinery, 145 tons, cost $22.40 per ton to install; and 10 tons of piping was placed for $44.77 per ton.

Island Mountain district.—The Hammond Exploration Co. was building in December, 1917, a small mill in Patterson Gulch, 2½ miles northwest of Gold Creek. The plant will be equipped with a Huntington mill and other necessary machinery for amalgamation and cyanidation. Concentration tables will be added in the spring of 1918.

Jarbidge district.—The only production was from the Flaxie property, which yielded ore containing gold and silver, recovered in an amalgamation mill. According to a recently published article[1] plans had been nearly completed for the building of a railroad from Twin Falls, Idaho, to Jarbidge. It was also said the Elkoro Mines Co. had reached the main ore body of the Long Hike mine in the lower workings, and that a wide body of excellent ore was exposed. It is estimated by the engineers in charge of the property that gold ore valued at $3,000,000 has been developed on the main levels. The mill of the company is nearing completion. This plant is situated on Jarbidge River at the mouth of Long Hike Gulch and is to operate in the spring of 1918 as a cyanidation plant treating 100 tons of ore daily. The ores will come from the Long Hike and Starlight mines.

Kinsley district.—Oxidized lead ore was shipped from the Kinsley-Star property in 1917.

Lee district.—Sulphide ore containing lead was shipped from the B. B. property.

Leroy district.—The Alabama, Jay Bird, and Pickup claims produced small lots of oxidized ore containing silver, lead, and copper.

Merrimac district.—A few tons of oxidized copper ore containing a little silver was shipped from the Copper Queen, Ironside, and Pacific properties.

Proctor district.—The Nick Del Duke prospect, situated a mile north of the Western Pacific Railroad at Proctor, produced a small quantity of silver ore, which was shipped to the smelter. There were also a few tons of silver ore shipped from the Silver Hoard property.

---

[1] Min. and Sci. Press., Mar. 10, 1917, p. 352.

Railroad district.—Seventeen producers reported the production of 3,324 tons of ore, containing $249 in gold, 39,252 ounces of silver, 595,931 pounds of copper, and 165,078 pounds of lead, valued in all at $209,478, or an average value per ton of $63.02. All this ore was of shipping grade and was produced largely by lessees operating the Gray Eagle property. There were also important shipments from the Bunker Hill, Kentucky, Ennor, Hale & Peterson, Sweepstake, Sylvania, Bald Mountain Chief, and Copper Bell mines.

Ruby Mountain Range district.—The principal production of ore came from the Michigan claim situated on the eastern slope of the Ruby Mountains on Battle Creek. The ore, which contained principally zinc, was concentrated in a 50-ton mill, and yielded lead and zinc concentrates.

Spruce Mountain district.—Operations at the Black Forest property resulted in the shipment of silver bearing lead ore and copper ore.

Tecoma district.—Lead ore from the S. & W. Lease and the California property represented the output of the district.

Tuscarora district.—Although there was great activity in the opening of some of the older properties, there was produced only 11 tons of shipping ore, containing principally silver. The larger part of the district output in 1917 came from the Surprise property.

Warm Creek district.—Oxidized zinc ore was shipped from the Polar Star property, operated by the Nevada Zinc Mining Co., but the output was much less than during 1916.

ESMERALDA COUNTY.

Mine production of Esmeralda County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	59	389,351	$2,684,688	170,677	1,391,392	408,534	17,680	$3,169,833
1917	61	349,655	1,986,001	157,218	762,627	448,431	15,402	2,363,882
Increase or decrease, 1917		−39,696	−698,687	−13,459	−628,765	+39,897	−2,278	−805,951

There were 349,655 tons of ore mined by 61 producers, 39,696 tons less than in 1916. Of the total ore, 165,299 tons treated by cyanidation and 3,399 tons by amalgamation, yielded $1,501,026 in gold and 52,158 ounces of silver, or an average value per ton of $9.15. There were 88,600 tons of ore treated at milling plants, which yielded 5,943 tons of concentrates containing gold, silver, and copper. These concentrates, with 10,472 tons of crude ore, were shipped to the smelters. The crude ore contained $268,335 in gold, 65,036 ounces of silver, 207,003 pounds of copper, 448,431 pounds of lead, and 15,402 pounds of zinc, valued in all at $418,573, or an average value per ton of $39.97. There was no placer production reported in 1917.

Crow Springs district.—Oxidized lead ore, produced from the Walker property, was hauled to McLeans on the Tonopah & Goldfield branch of the Southern Pacific Railroad.

Cuprite district.—Ore containing lead was produced in 1917 from the Ella claim, which is opened by a shaft 60 feet deep.

Desert district.—The Carrie property was a producer of sulphide ore, containing lead, silver, and some gold. This property is opened by a 200-foot shaft.

Goldfield district.—All metals produced in 1917 decreased in quantity and the value was $897,481 less than in 1916, as is shown in the following table:

Mine production of Goldfield district, Nev., 1904–1917.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	383,456	$2,651,158	129,781	1,317,400	2,418	$3,060,801
1917	339,488	1,900,082	78,184	728,255	....	2,163,320
Decrease, 1917	43,968	751,076	51,597	589,145	2,418	897,481
Total, 1904–1917	....	80,252,177	1,206,713	6,864,858	26,080	82,246,712

Seventeen producers in 1917 reported the production of ore with an average value per ton of $6.37, against an average value of $7.98 in 1916. The larger part of the output, or 161,955 tons, was treated at milling plants by the cyanidation process and yielded 69,642.81 ounces of gold and 30,466 ounces of silver. There were also 88,600 tons of ore concentrated, yielding 5,921 tons of concentrate, which contained 9,996.08 ounces of gold, 38,578 ounces of silver, and 511,470 pounds of copper. In addition to the ore, there were 81,885 tons of old tailings re-treated. The ore of shipping grade amounted to 7,048 tons and contained 12,277.59 ounces of gold, 9,140 ounces of silver, and 174,530 pounds of copper. The principal producers of these ores were the Goldfield Consolidated, Atlanta, Florence, Diamondfield Daisy, Great Bend, and Jumbo Extension.

Regular shipments of sulphide copper ore were made from the Atlanta mines, and considerable gold ore came from the Florence mine, under control of a new organization.

From the Goldfield Consolidated mines[1] a total of 250,550 tons of mill ore was produced in 1917, averaging $8.14 per ton in gold and silver, with a recovery of $7.04 per ton. At the same time, 81,885 tons of tailing of an average value of $1.27 were taken from the tailing pond, yielding a profit of 32 cents per ton. The total recovery of gold and silver from the product treated was $1,825,296.59. The following extract is from the annual report of the company:

> No dividends were paid during the year owing to the reduced earnings and the desire of the management to conserve its financial resources to the end that other possible operations may result in greater earning capacity.

---

[1] Goldfield Consolidated Mines Co. Eleventh Ann. Rept., for year ending Dec. 31, 1917.

Production of Goldfield Consolidated Mines Co., 1917.

	Production (short tons).	Total value.	Average per ton.
Tons of ore milled	250,550	$2,039,103.49	$8.14
Loss in tailing and smelter discount		276,133.44	1.10
Value recovered		1,762,970.05	7.04
Tons of tailing treated	81,885	103,843.49	1.27
Loss in tailing		41,516.95	.51
Value recovered		62,326.54	.76
Total value recovered from ore and tailing		1,825,296.59	
Cost of ore purchased and amount paid lessees		85,649.32	
Value realized		1,739,647.27	
Net costs		1,543,012.82	
Net realization from operations		196,634.45	
Expenditures, account exploration and development		68,133.69	
Net realization		128,500.76	

Within the year 14,770 tons of ore of average value of $14.75 and gross value of $217,905.33 were produced by lessees, of which amount $82,237.40 was paid to lessees. From this sum lessees paid expenses of labor and powder. The records show approximately 18,000 shifts of labor have been employed by lessees during this period of production, which indicates that taken as a whole the lessees have made no profit. Some individual leases have been profitable, but to no great extent. This result has been most disappointing, since it has been hoped lessees would open up new ore bodies. There are now 40 sets of lessees at work employing 80 men, and as rapidly as the company withdraws from a section of a mine it is opened to lessees, and this policy will be continued.

It is not possible to offer more liberal terms to lessees, since the present deduction of $4 per ton is scarcely enough to pay the expenses of handling lease ore. Costs have naturally increased with the reduction in tonnage milled per day. Further, it does not seem probable leasing would be stimulated even if more liberal terms were made, since many of the blocks already opened have been leased several times. * * *

The entire tonnage produced within the year has been milled at your company's milling plant. Of this, 161,950 tons were treated by the cyanide process and 88,600 tons were treated by flotation. The flotation plant, operating on low-grade copper ores, was placed in service in March and has been in continuous operation since that date. For the first three months the concentrate resulting from the flotation process was treated locally in your concentrate treatment plant with indifferent success. It has been demonstrated, not only in your plant but in the laboratory and from tests made by independent metallurgists that this product can not be treated profitably by the cyanide process unless subjected to a chloridizing roast, which is impracticable. In June arrangements were made to market the flotation concentrate through custom smelters.

Total production of Goldfield Consolidated Mines Co. from prior to Oct. 31, 1908, to Dec. 31, 1917.

Property.	Ore sold or treated.	Average value.	Total value.
	Dry tons.	*Per ton.*	
Combination	572,500	$25.65	$14,682,718.08
Mohawk	1,288,825	21.50	27,709,199.48
Clermont-Jumbo No. 2	585,402	34.23	20,040,135.30
Laguna-Red Top	480,593	18.19	8,741,524.81
Dumps	135,092	4.75	641,614.37
Contractors	31,940	20.91	667,873.17
			72,483,065.21

During its fiscal year the Jumbo Extension[1] produced 8,143 dry tons of smelting ore averaging per ton $26.94 in gold and silver, with a little copper. There were also 807 tons of dump ore sold on a flat rate of $1 per ton.

Gold Mountain district.—Ore of shipping grade reported from 11 properties amounted to 187 tons, containing $4,811 in gold, 3,150 ounces of silver, 4,136 pounds of copper, and 23,149 pounds of lead, valued in all at $10,527, or an average value per ton of $56.29. The principal producers were the Butte, Little George, and May Day.

Hornsilver district.—The principal producers, the Silver Mines Corporation and the Orleans property, yielded milling ore, the larger part of which was treated in the 100-ton cyanide plant of the former property. This is a new mill, and it was reported that custom ore would also be treated. The ore from the Orleans property was shipped to the Belmont mill at Tonopah. All of the ore produced gold and silver bullion.

Klondyke district.—The largest part of the district output was silver ore and oxidized lead ore from the Original Klondyke property. The mine is opened by a vertical shaft 150 feet deep and an adit 300 feet long.

Lida district.—Seven producers reported the production of 55 tons of ore, containing $145 in gold, 7,052 ounces of silver, 824 pounds of copper, and 19,026 pounds of lead, valued in all at $7,817, or an average value per ton of $142.12. The Eagle & Tip Top was the principal producer.

Lone Mountain district.—Nine producers reported the output of 1,016 tons of ore, containing $1,123 in gold, 19,585 ounces of silver, 24,159 pounds of copper, 286,245 pounds of lead, and 15,402 pounds of recoverable zinc, valued in all at $50,044, or an average value per ton of $49.26. The principal part of the production came from the General Thomas property and consisted of oxidized lead ore. The Lone Star was also a producer, yielding copper ore, copper-lead ore, and some zinc ore.

Montezuma district.—The Montezuma mine dump yielded a small quantity of sorted ore, which was shipped to the smelter.

Palmetto district.—The property of the Desert Holly Mining Co. was operated and produced a small quantity of lead ore, and some ore of similar character was shipped from the Treasure State claim.

Silverpeak district.—The Mary mine, operated by lessees, yielded ore which was milled and produced gold and silver bullion. Some ore was also shipped to the smelter from the Black Warrior property.

EUREKA COUNTY.

Mine production in Eureka County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	36	22,082	$114,752	143,686	79,066	2,804,981	34,935	$426,972
1917	45	7,165	30,282	72,269	72,841	1,783,933	....	263,136
Decrease, 1917	....	14,917	84,470	71,417	6,225	1,021,048	34,935	163,836

[a] Includes placer production.

---

[1] Jumbo Extension Mining Co. Ann. Rept. for year ending June 30, 1917.

Forty operators produced 7,165 tons of ore, 14,917 tons less than was produced by 30 operators in 1916. The total average value per ton increased from $18.86 in 1916 to $36.34 in 1917 and the gold and silver value in this ore from $9.01 to $12.15 per ton. Of the ore, 450 tons were treated in gold and silver mills and yielded bullion containing $2,399 in gold and 39 ounces of silver, which had an average total value of $5.40 per ton. There were 5,861 tons shipped directly to smelters, containing $19,308 in gold, 66,757 ounces of silver, 57,997 pounds of copper, and 1,702,115 pounds of lead, valued in all at $236,531, or an average value per ton of $40.36. Placed bullion reported from five sources amounted to $2,761 in gold and 16 ounces of silver.

Antelope district.—Lessees operating the Prince of Wales group shipped a small quantity of copper sulphide ore.

Cortez district.—The post office of Cortez is in Lander County, but some of the mines are in Eureka County. Ore was produced in 1917 and was reported from Lander County.

Eureka district.—There were 31 producers reporting the production of 3,304 tons of ore, containing $20,131 in gold, 39,708 ounces of silver, 31,771 pounds of copper, and 693,757 pounds of lead, valued in all at $121,188, or an average value per ton of $36.68. There were 2,450 tons of ore and 814 tons of old slag shipped directly to the smelters. Only 40 tons were milled, yielding 17 tons of lead concentrate. The principal producers were the Connelly, California & Silver King, Bullwhacker, and Holly mines. Most of the old slag came from the Richmond Eureka property, and some from the Diamond.

Lynn district.—Five placer producers reported the production of gold bullion, and one quartz mine the production of gold ore, valued in all at $9,544. All the ore was milled in an amalgamation plant on the Big Six property. This mill, constructed in 1917, treated about 5 tons of ore a day during its operation. In 1916 the output of ore and placer bullion from the district was $19,398 in gold and 63 ounces of silver. Placer producers report a very small flow of water for the season of 1917 as the cause of the large decrease in the output of gold.

Maggie Creek district.—The Copper King property, operated by a lessee, yielded a small tonnage of oxidized copper ore of shipping grade.

Mineral Hill district.—Three producers reported 3,010 tons of ore, containing $360 in gold, 27,837 ounces of silver, 2,448 pounds of copper, and 1,062,996 pounds of lead, valued in all at $115,384, or an average value per ton of $38.33. The largest part of the production came from the Union Mines Co. There was also some ore from the property of the Mineral Hill Consolidated.

Safford district.—Two small shipments were made from the Zenoli property. There were also small shipments from two other claims.

HUMBOLDT COUNTY.

Mine production in Humboldt County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	95	109,683	$398,231	869,424	135,180	75,734	$1,008,792
1917	104	104,564	246,645	859,837	567,610	511,221	1,154,074
Increase or decrease, 1917.	....	−5,119	−151,586	−9,587	+432,430	+435,487	+145,282

[a] Includes placer production.

Humboldt County had 100 producers of ore in 1917, against 84 producers in 1916. The total average value per ton increased from $9.13 in 1916 to $11.03 in 1917. Milling plants using amalgamation and cyanidation, but principally the latter process, treated 93,677 tons of ore, which yielded $231,381 in gold and 785,988 ounces of silver, having an average value per ton of $9.38. Some gold and silver concentrate and a little lead concentrate were also produced at the milling plants and shipped to smelters. Ore of shipping grade aggregated 5,935 tons and contained $8,532 in gold, 59,177 ounces of silver, 434,110 pounds of copper, and 120,412 pounds of lead, valued in all at $186,161, or an average value per ton of $31.37. There were also some shipments of old tailing and slag containing copper and lead. The placer output reported from 4 sources amounted to $1,206 in gold and 10 ounces of silver, as against $7,174 in gold and 90 ounces of silver in 1916.

Amos district.—In 1917 the 30-ton amalgamation and concentration mill of the Oklahoma property was built in Buckroo Canyon of the Pine Forest range. The plant is expected to be in operation in the spring of 1918.

Antelope district.—The Majuba Hills property, recently under option to the Mason Valley Mining Co., was operated and produced silver-bearing copper ore, which was shipped to its smelter at Thompson. Some oxidized lead ore was produced from the Last Chance property. The 25-ton concentration mill of the Antelope Springs Co. was enlarged in 1917 to a 50-ton oil flotation plant using the K. and K. system in addition to four Wilfley tables, a ball mill, and one Blake crusher. The plant is reported to be ready for operation.

Central or Mill City district.—Copper ore was produced from the 56 Copper Mines Co's. property in 1917.

Dun Glen district.—The Sheba mine was active and some ore was treated in its concentration mill, and yielded lead concentrate which carried considerable silver.

Gold Run district.—Seventeen producers of ore reported 7,116 tons containing $2,624 in gold, 28,331 ounces of silver, 488,760 pounds of copper, and 42,725 pounds of lead, valued in all at $163,075, or an average value per ton of $22.92. The ore of shipping grade aggregated 4,360 tons, and also 2,670 tons of old tailing containing copper and silver were shipped from the old dump of the

Glasgow & Western milling plant. The largest producers of ore were the Yerington Mountain Copper and Adelaide properties. The Caroline property was also an important shipper of oxidized copper ore. A small production of gold, taken out in development work, was reported from the Gold Run placer.

Kennedy district.—Oxidized lead ore, containing silver and gold, came from the Henrietta and Abe Lincoln group, and a small output of bullion from the experimental plant of the Roylance Reduction Co. Gold ore from the Virginia property was treated at this mill by an electrochemical amalgamation process.

National district.—The milling plant of the National Mines Co. was reported idle during the year. The property was operated by a lessee who produced a small quantity of gold and silver bullion.

Rochester district.—Nineteen ore producers reported 88,371 tons containing $152,855 in gold, 799,865 ounces of silver, 646 pounds of copper, and 14,521 pounds of lead, valued in all at $813,369, or an average value per ton of $9.20. The placer output amounted to $717 in gold and 6 ounces of silver. There were 87,839 tons of ore milled, yielding gold and silver bullion, and 532 tons of ore, containing gold, silver, copper, and lead, were shipped directly to the smelters. There were also some values in sweepings from the mill ponds of the cyanide plants. The largest producer of milling ore was the Rochester Mines Co., which operated its 200-ton cyanidation mill almost continuously during the year. The next largest producer was the Packard property, equipped with a 100-ton cyanide plant. Some gold and silver bullion was produced in a two-stamp amalgamation mill treating ore from the Lincoln Hill mine. The other producers in the district were the American in South American Canyon, Buck & Charley, Octopus, and Rochester Merger. In drifting for a vein on the Bonanza claim, some gold was recovered by sluicing. This property is 2 miles north of Rochester. Machinery and other necessary equipment for a 500-ton cyanidation plant was put in place on the Rochester-Combined mill site, near the Packard mill, during 1917. It is expected this mill will begin operations some time in 1918.

Rosebud district.—Seven producers reported the production of 53 tons of ore of shipping grade, containing $16 in gold, 2,694 ounces of silver, 5,386 pounds of copper, valued in all at $3,706, or an average value per ton of $69.92. The principal properties operated were the Abe Lincoln and the Grubstake, and the remaining part of the output came from the dumps of small prospects.

Seven Troughs district.—The reports received from 18 producers gave an output of 5,552 tons of ore, containing $81,830 in gold, and 6,554 ounces of silver, valued in all at $87,231, or an average value per ton of $15.73. All of the ore, with the exception of 6 tons, which was shipped to a smelter, was milled, and produced gold and silver bullion and a few tons of gold and silver concentrate. The Seven Troughs Coalition, Delaware, Mazuma Hills, Fairview, Monarch, and Signal Peak properties were the principal producers of milling ore.

Sonoma Mountain district.—The Wolverine property yielded a small quantity of copper ore carrying silver.

Sierra district.—Six producers reported 149 tons of ore and old tailings, containing $406 in gold, 2.540 ounces of silver, and 8,625 pounds of lead. There was also a small quantity of copper in one shipment. The total value of the metals was $3,265, or an average value per ton of $21.91. There were 44 tons of ore shipped directly to the smelters. The principal producers were the Gem Five, Tululah, and Sunshine properties.

Trinity district.—The Electric Mining and Reduction Co. operated the old Arabia property, from which ore containing antimony and lead was shipped to the smelter. Shipments of old slag from early operations of the Montezuma smelter contained antimonial lead and silver. Some crude ore from the Montezuma mine was also shipped.

Unionville district.—The Arizona property yielded a few tons of silver ore, which was shipped directly to the smelter.

Warm Springs district.—The Ashdown & Vicksburg property was operated for a short period, yielding gold and silver bullion.

Winnemucca Mountain district.—Ten producers reported 350 tons of ore, containing $3,013 in gold, 4.039 ounces of silver, and 4,050 pounds of lead, valued in all at $6,689, or an average value per ton of $19.11. There were 258 tons of ore milled, producing gold and silver bullion, and 92 tons of lead ore were shipped directly to the smelter. Bullion was produced from the Neshobe and Winnemucca Mountain properties.

LANDER COUNTY.

Forty-seven producers reported the output of 23,848 tons of ore, 7,749 tons more than was reported by 30 producers in 1916. The total average value of the ore increased from $21.22 in 1916 to $35.12 in 1917. At gold and silver mills, 2,801 tons of ore yielded $11,622 in gold and 1,482 ounces of silver, an average value of $4.59 per ton. The ore of shipping grade amounted to 19,389 tons, containing $17,917 in gold, 112,336 ounces of silver, 2,479,657 pounds of copper, and 248,529 pounds of lead, valued in all at $808,802, or an average value per ton of $41.71. The placer output reported by 33 operators was $66,746 in gold and 460 ounces of silver, against a production in 1916 by 11 operators of $153,698 in gold and 1,050 ounces of silver.

Battle Mountain district.—Producers of ore from 20 properties reported 18,162 tons, containing $4,881 in gold, 18,595 ounces of silver, 2,431,247 pounds of copper, and 98,978 pounds of lead, valued in all at $692,445, or an average value per ton of $38.13. The greater part of this ore was of shipping grade, amounting to 17,597 pounds, containing 122.62 ounces of gold, 16,109 ounces of silver, all of the copper, and 40,486 pounds of lead. There were 458 tons of ore milled, which produced lead concentrate carrying silver, and 107 tons of ore yielded gold and silver bullion. The largest shipper of oxidized copper ore was the Copper Canyon Mining Co. There were also important shipments from the Copper Queen property. Reports from 33 placer producers showed an output of $66,746 in gold and 460 ounces of silver. Most of this gold output was made by drift mining, and the gold was recovered by sluicing the gravel of an ancient river bed situated in Copper Canyon. Smaller lots of gold were obtained from other placers in the Battle Mountain Range, partly from Piute Gulch. On the Gold Top property a 36-ton amalgamation and concentration plant, built in Pedro Gulch about 9 miles from Battle Mountain, was completed in September, 1917. An ordinary jaw crusher with a ball mill will prepare the ore for further treatment on an Eccleston concentration table. The plant will not operate until 1918.

Cortez district.—Lead ore was shipped from the Utah property, and reports of shipments of lead ore and siliceous silver ore were also made by the Tenabo Mining & Milling Co., and the Mount Tenabo Mining Co. The ore is all shipped to the smelter from Beowawe, on the Southern Pacific Railroad.

Hilltop district.—Most of the ore mined in the district was milled, yielding gold and silver bullion, chiefly by cyanidation. There were also 457 tons of ore, containing gold, silver, copper, and lead, shipped directly to the smelters. The Kimberly Consolidated Mines Co. treated the largest part of the milling ore, and the Gray Eagle mine produced a silver ore and a lead ore.

Lander or Bullion district.—From the Maysville property, silver ore containing a small quantity of copper and gold was shipped directly to the smelter. The Exile and Quartz claims were also producers.

Lewis District—Ore of shipping grade, containing principally silver and a little lead, copper, and gold, was shipped to the smelters from the Eagle, Monitor, and Star Grove groups.

Reese River District—Seven producers of ore reported 101 tons, containing $155 in gold, 3,455 ounces of silver, 284 pounds of copper, and 10,476 pounds of lead, valued in all at $3,980, or an average value per ton of $39.41. The properties operated were the Austin Dakota, Eclipse, and Austin claims. A 75-ton cyanidation plant, situated at New Pass, 21 miles from Austin, was completed in February, 1918, by the Nevada Austin Mines Co.

LINCOLN COUNTY.

Mine production in Lincoln County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	23	162,153	$34,305	559,045	806,938	10,356,926	2,002,105	$1,583,574
1917	23	154,087	48,899	523,399	440,197	10,714,152	1,332,521	1,657,688
Increase or decrease, 1917		−8,066	+14,594	−35,646	−366,741	+357,226	−669,584	+74,114

In 1917, 23 operators reported 8,066 tons of ore less than was produced by the same number of operators in 1916. The average value per ton increased from $9.77 to $10.76, and the gold and silver value from $2.48 to $3.12 per ton. The greater part of the ore, 137,090 tons, was of shipping grade and contained $35,763 in gold, 483,953 ounces of silver, 427,946 pounds of copper, 10,099,224 pounds of lead, and 183,472 pounds of zinc, valued in all at $1,438,616, or an average value per ton of $10.49. Ore treated at gold and silver mills aggregated 453 tons and yielded bullion valued at $4,742. At concentrating plants, 5,988 tons of ore yielded 2,926 tons of concentrates containing $7,048 in gold, 34,214 ounces of silver, 2,984 pounds of copper, 499,131 pounds of lead, and 1,149,049 pounds of zinc, valued in all at $196,183, or an average value per ton of $67.05. No placer production was reported in 1917.

Atlanta district.—Some old tailings concentrated from the Silver Park dump yielded lead concentrate carrying silver and a little gold.

Caliente district.—The Gold Chief and Peerless properties were the chief producers of gold-silver ore and some lead ore.

Groom district.—The Groom mine continues to be a good producer of high-grade lead sulphide ore containing silver. The property is opened by a shaft 200 feet deep. All of the ore is hauled by motor truck to the railroad and contains from 35 to 61 per cent of lead and 11 to 22 ounces of silver, with 0.5 per cent of copper, 3 per cent of zinc, 2.5 per cent of iron, and 12 per cent of insoluble, 8 per cent of sulphur, and 9 per cent of lime.

Jack Rabbit district.—Four producers reported 6,709 tons of ore, containing $1,466 in gold, 45,059 ounces of silver, 381,315 pounds of copper, and 146,368 pounds of lead, valued in all at $155,282, or an average value per ton of $23.15. The principal part of the output was reported from the Uvada Copper property, which yielded ore of shipping grade, most of which was oxidized copper ore and the remainder oxidized lead ore. The Ida May, Fortuna, and Silsbee properties were also producers.

Pioche district.—Eleven producers reported 144,996 tons of ore, containing $41,989 in gold, 450,517 ounces of silver, 40,233 pounds of copper, 9,099,551 pounds of lead, and 1,332,521 pounds of recoverable zinc, valued in all at $1,342,677, or an average value per ton of $9.26. The greater part of the total output, or 128,702 tons, was of shipping grade, which, with 10,306 tons of old slag was shipped directly to the smelters. There were also 2,911 tons of concentrate produced containing gold, silver, copper, lead, and zinc. The greatest part of the district output was from the Prince Consolidated, which shipped low-grade iron manganese ore, containing small quantities of gold, silver, copper, and lead. Old tailings were re-treated in the Bullionville mill by oil flotation, and yielded considerable lead concentrate containing silver and gold. Equal quantities of ore were shipped from the Mendha and Hamburg mines, and from a lease on the Amalgamated Pioche property, the owners of which also shipped zinc-lead concentrate on company account.

Viola district.—A small shipment of copper ore carrying silver was shipped from the Viola property.

LYON COUNTY.

The output of 329,910 tons of ore, reported by 64 producers in 1917, was 298,488 tons more than was reported by 44 producers in 1916. The total average value per ton decreased from $30.61 in 1916 to $16.22 in 1917, and the gold and silver value of the ore from $3.28 to 17 cents per ton. There were 2,353 tons of ore and 4,620 tons of old tailings treated at amalgamation and cyanidation plants and yielded $49,441 in gold and 4,160 ounces of silver, valued in all at $52,869, or an average value per ton of $7.58. There were 322,371 tons of ore shipped to smelters, containing $940 in gold, 1,600 ounces of silver, 19,350,592 pounds of copper, and 2,250 pounds of lead, valued in all at $5,285,165, or an average value per ton of $16.39. The placer output was small.

Pine nut district.—A small quantity of lead ore was shipped from a prospect in the district.

Ramsey district.—From the Ramsey-Comstock property tailings and some gold bullion were recovered.

Silver City district.—Twenty-eight producers reported 3,091 tons of ore and old tailings, which yielded gold and silver bullion. The output consisted of $44,704 in gold and 4,149 ounces of silver. Most of the ore was treated in the district by amalgamation, but the tailings were cyanided.

Talapoosa district.—Two mine operators reported a small production of oxidized copper ore containing a little silver from prospects in the district.

Yerington district.—Thirty-two deep-mine producers reported 322,945 tons of ore, containing $1,162 in gold, 1,571 ounces of silver, 19,396,536 pounds of copper, and 2,046 pounds of lead, valued in all at $5,297,888, or an average value per ton of $16.40. The greater part of this ore, or 322,367 tons, was of shipping grade, most of it being smelted at Thompson. There were also 566 tons of ore leached at the Nevada Douglas experimental plant in the district, and a small quantity of bullion was recovered at two other plants from ore treated by amalgamation. The largest part of the district output, consisting of copper ore, was from the Mason Valley property, with considerable quantities from the Bluestone and Nevada Douglas properties. The Empire Nevada, O'Connell, and Montana Yerington also produced copper ore.

The Mason Valley mines[1] produced 114,273 tons of copper ore, which was treated at the Thompson smelter. From outside sources 194,075, tons of copper ore were smelted, yielding altogether 7,038 tons of blister copper, containing 1,036.64 ounces of gold, 46,257.71 ounces of silver, and 13,914,764 pounds of copper. The company is operating, besides the Mason Valley mines, the Majuba Hills property, a group of 88 claims situated 16 miles from Humboldt on the Southern Pacific Railroad, in Humboldt County, and the Gray Eagle group in the Happy Camp district of Siskiyou County, Cal.

From the Nevada-Douglas property[2] there were shipped 52,451 tons of copper ore, from which the smelters returned to the company 4,430,725 pounds of copper, valued at $1,138,248.88. All of the smelting ore was shipped to the Mason Valley smelter at Thompson. Experiments were continued at the 50-ton leaching plant at Ludwig, and 28 tons of 68 per cent cement copper were reported[3] to have been shipped. Construction work on the leaching plant was not complete at the close of 1917 and the success of the process is still in doubt.

MINERAL COUNTY.

One hundred twenty-nine producers reported 274,571 tons of ore, or 8,388 tons more than was reported by 93 producers in 1916. The total average value per ton increased from $6.56 in 1916 to $7.37 in 1917, and the value of the gold and silver from $3.73 to $3.82. The larger part of the ore (202,748 tons) was treated at gold and silver mills, most of it by cyanidation, and yielded $681,757 in gold and 188,905 ounces of silver. This bullion included the recoveries made from 37,217 tons of old tailings re-treated by cyanidation. There were 32,154 tons of crude ore shipped to smelters, which contained $28,915 in gold, 171,632 ounces of silver, 3.458,565 pounds of copper, and 356,131 pounds of lead, valued in all at $1,145.157, or an average value per ton of $35.61. The output reported from 4 placers amounted to $428 in gold and 14 ounces of silver, against $743 in gold and 11 ounces of silver in 1916.

---

[1] Mason Valley Mines Co. Eighth Ann. Rept., for year ending Dec. 31, 1917.

[2] Nevada Douglas Copper Co. financial statement for year ending Dec. 31, 1917.

[3] Letters of Nevada-Douglas mines published in market stock letter of A. J. Orem & Co., Boston, Mass., Oct. 24 and Dec. 5, 1917.

Aurora or Esmeralda district.—During 1917 the Aurora Consolidated mines[1] produced 175,477 tons of ore, containing $2.819 in gold and silver per ton, of which 50.3 cents per ton was lost in tailing. The total value recovered by cyanidation was $406,277.52, at a cost of 92.6 cents per ton for mining and $1.297 per ton for milling expenses. The property has been operated at a loss, according to the annual report of the company, which continues as follows:

> Within the year 175,477 tons of ore of $2.819 grade were produced, from which resulted an operating loss of $18,788.26.
>
> Interest on indebetedness was paid to the amount of $18,279.12, making a total loss for the year of $37,067.38.
>
> In August it became apparent that the ore exposed in your property would not yield a profit. It was deemed advisable to push development work as rapidly as possible toward the old Juniata workings for the purpose of proving or disproving the stories regarding the vein and ore values in this section which has been caved and under water since 1872.
>
> On the 4th of November an intermediate 85 feet above the main haulage tunnel encountered the shaft, which fortunately had not caved for 70 feet above this intermediate and gave access to what is believed to be the second level of the old Juniata mine. At this elevation the vein is exposed for 260 feet, of which 130 feet had been stoped in the early days. The vein is 8 feet wide at the most westerly exposure, where it has been square set and filled by the early day operators. At this elevation in the west end there is a 90-foot unstoped section 8 feet wide, cut samples from which average $4.50. Samples from the fill range from $4 to $6, and one cut across the back for 10 feet averages $20. The most encouraging features of the exposure are the vein apparently widens to the east and also widens with depth. * * *
>
> The encouraging development in the Juniata ground, together with the lease on the Silver Lining claims, gives your company the most promising outlook for profitable operations that it has ever had. * * *
>
> After the mill operations have ceased it will be possible to realize $100,000 through a thorough clean-up of the plant. This clean-up will result from dismantling the mill and burning all material which has been in contact with the rich solutions, and it can not be accomplished until the plant is entirely out of commission.

Bell district.—From the Olympic mine considerable ore was produced in 1917, yielding gold and silver bullion in a 100-ton cyanide plant. This mine is opened by a 235-foot incline shaft, and the mill has been operating continuously since April 27.

Buena Vista district.—All the ore shipped from three properties was valued at $4,137 for its content of gold, silver, copper, and lead. The Queen and Friday properties were producers of lead ore carrying principally silver and a little copper.

Cedar Range district.—This district is situated about 24 miles east of Mina, on the Tonopah & Goldfield branch of the Southern Pacific Railroad. The Copper Bell property, the only producer in 1917, yielded copper ore of shipping grade containing gold and a little silver.

---

[1] Goldfield Consolidated Mines Co. Eleventh Ann. Rept., for year ending Dec. 31, 1917.

Columbus district.—Eleven producers reported the production of 5,032 tons of ore of shipping grade and 39,176 tons of old tailings, part of which was treated by cyanidation and the remainder smelted. Altogether the district yielded $34,071 in gold, 255,765 ounces of silver, 39,379 pounds of copper, and 244,923 pounds of lead, valued in all at $276,635, or an average value per ton of $6.26. The old tailings milled came from the property owned by the Belleville Tailings Association, and that shipped directly to the smelter was from the dump owned by the Candelaria Syndicate. The shipping ore originated from the Lucky Hill, Argentum, Diablo, and Simon lead properties.

Hawthorne district.—The reports of 15 producers gave the production of 535 tons of ore containing $1,376 in gold, 17,445 ounces of silver, 35,558 pounds of copper, and 28,828 pounds of lead, valued in all at $27,937, or an average value per ton of $52.22. The production of placer gold was small. The Emerald Copper, Buster Boy, Garfield, and Lucky Boy were producers of ore. From the Pamlico region some drift mining in eroded material yielded gold by dry washing.

Mount Grant district.—The treatment of a small quantity of ore from the Mammoth property in a 2-stamp mill equipped for cyanidation yielded a small quantity of gold bullion. There were also a few tons of ore produced from the Congress property.

Pine Grove district.—At the Wheeler gold mines some gold and silver bullion was recovered from old tailings re-treated. The largest producer, the Pittsburg-Dolores, produced gold and silver bullion from the treatment of ore in its 75-ton cyanide plant.

Rand district.—Nine producers reported 2,795 tons of ore, containing $2,189 in gold, 2,390 ounces of silver, 374,395 pounds of copper, and 9,034 pounds of lead, valued in all at $107,145, or an average value per ton of $38.33. The bulk of the ore produced was of shipping grade, and only 8 tons were treated in a mill and yielded gold and silver bullion. The largest part of the output, consisting of copper ore containing gold and silver, came from the Copper Mountain property. Other producers were the Golden Pen, Nevada Rand, and Silver Cloud. The Copper Mountain property,[1] bonded by the Jumbo Extension Mining Co., comprises five patented claims and 13 nonpatented claims, which were being prospected in 1917. At the same time promising results were obtained from the sale of copper ore shipped by lessees. Nolan, a station on the Southern Pacific Railroad, is the nearest loading station.

Rawhide district.—From five properties there were 298 tons of ore produced, containing $8,748 in gold and 10,397 ounces of silver, valued in all at $17,315, or an average value per ton of $58.10. The greater part of the ore was treated by cyanidation at the mill of the Nevada New Mines Co., and only 45 tons of ore, principally siliceous silver ore, were shipped directly to the smelter. A little placer gold was also recovered from washing eroded surface material.

Santa Fe district.—Forty-nine producers reported 19,932 tons of ore, containing $2,009 in gold, 50,007 ounces of silver, 2,590,756 pounds of copper, and 35,799 pounds of lead, valued in all at $753,570, or an average value per ton of $37.81. Most of this ore was copper bearing and was shipped to the smelter at Thompson, and a small quantity of ore containing lead was shipped to a Salt Lake smelter. There were only 78 tons from which gold and silver bullion was recovered. The most important producers of copper ore were the Wall Street, Calavada, Tip Top, Green Tunnell, Iron Gate, Mayflower, Champion, Iroquois, St. Patrick, Vacation, and Taft properties.

---

[1] Jumbo Extension Mining Co. Ann. Rept. for year ending June 30, 1917.

Silver Star district.—There were 2,651 tons of ore reported by 22 operators, which contained $2,218 in gold, 9,038 ounces of silver, 283,473 pounds of copper, and 24,033 pounds of lead, valued in all at $89,120, or an average value per ton of $33.62. The larger part, or 2,541 tons of ore, was shipped directly to the smelter and contained 100.65 ounces of gold, 9,033 ounces of silver, 280,075 pounds of copper, and 24,033 pounds of lead. There were 80 tons of ore treated in a concentration mill, producing copper concentrate, and a small quantity of bullion was recovered in a gold and silver plant. The principal producers of copper ore were the Olga, Copper King, and Silver Dike.

Walker Lake district.—The Northern Light property yielded a small quantity of oxidized copper ore shipped directly to the smelter.

NYE COUNTY.

Mine production in Nye County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	100	564,450	$2,505,714	8,868,267	6,023	135,355	....	$8,351,855
1917	114	514,361	2,007,234	7,172,642	15,529	430,025	6,042	7,959,328
Increase or decrease, 1917		−50,089	−498,480	−1,695,625	+9,506	+294,670	+6,042	−392,527

[a] Includes placer production.

The output of 514,361 tons of ore was reported in 1917 by 79 opertors of deep mines. This was 50,089 tons less than was reported by 73 operators in 1916. The total average value per ton increased from $14.47 in 1916 to $15.04 in 1917. The value of the ore in both years was practically that of the gold and silver. Nearly all of the ore (509,692 tons) was treated at gold and silver mills, and yielded bullion containing $1,742,907 in gold and 6,844,701 ounces of silver, having an average value per ton of $14.49, and 851 tons of concentrates, which were shipped to smelters, containing 1,747.72 ounces of gold and 261,067 ounces of silver. These and 34 tons of concentrates produced at concentration mills contained altogether $36,136 in gold, 269,257 ounces of silver, and 342 pounds of copper, having a total value of $258,097, or an average value per ton of $291.63. The ore of shipping grade amounted to 1,605 tons and contained $8,425 in gold, 51,495 ounces of silver, 15,187 pounds of copper, 430,025 pounds of lead, and 6,042 pounds of zinc, valued in all at $92,602, or an average value per ton of $57.70. The placer gold reported from 35 operators amounted to $219,131 in gold and

5,754 ounces of silver, against a production in 1916 of $179,165 in gold and 4,501 ounces of silver.

Antelope Springs district.—A small lot of sorted ore containing 70 ounces of silver a ton was shipped from the Antelope mine.

Bellehellen district.—Two properties near Clifford produced milling ore, part of which was treated in a small stamp mill on the property, and about 400 tons were shipped to the West End mill at Tonopah. These ores carried principally silver with some gold.

Belmont or Philadelphia district.—The Monitor Belmont property, on which operations were commenced in 1916, was closed in 1917, having probably worked over the best part of the old tailing dumps.

Bullfrog district.—There were only 34 tons of ore produced in the district in 1917. The largest part, or 29 tons, containing gold, silver, and copper, was shipped to the smelter, and the remainder produced a little gold and silver bullion. This bullion was from a clean-up around the mill of the Pioneer Consolidated Co., which was said to be closed as a result of the Nevada California Power Co. discontinuing the electric power service in the district.

Cloverdale district.—The Orizaba mine, worked by lessees, produced a small quantity of silver ore, containing a little gold.

Ellendale district.—The Dividend property yielded a small quantity of oxidized copper ore of shipping grade containing silver with a little gold.

Johnnie district.—There were three producers, the Johnnie and the Eureka Johnnie treating gold ore at their respective milling plants, and the Black Jack producing lead sulphide ore of shipping grade containing silver. A small amalgamation mill was built in 1917 a short distance southwest of Johnnie to treat Eureka ore. It was equipped with a crusher and two 1,000-pound stamps, and worked a few tons of ore containing gold and silver.

Mammoth district.—The Illinois property produced shipping ore containing lead and silver with a little copper and gold. On this property there is a 100-ton lead smelter, which has been closed for 10 years. The larger part of the crude ore shipped had been in the smelter bins since the closing of the furnaces. Included with the ore was some material from the clean-up of the flue chambers and furnaces.

Manhattan district.—Nineteen mine producers reported 25,427 tons of ore, containing $113,008 in gold and 1,899 ounces of silver, valued in all at $114,573, or an average value per ton of $4.51. In 1916 there were 11 producers with an output of 41,725 tons of ore, valued at $123,299. The placer output reported by 31 producers in 1917 amounted to $64,677 in gold and 1,202 ounces of silver, having a total value of $65,667, against an output in 1916 by 25 placer operators who produced $75,359 in gold and 1,380 ounces of silver, with a total value of $76,267. Most of the ore produced in 1917 came from the White Caps and the Mayflower & Big Pine properties. The White Caps mine has been newly equipped with a 150-ton all-slime cyanidation plant. This mill was finished in September, 1917, and started the treatment by cyanidation after the ore was roasted. The mine is opened by a vertical shaft 500 feet deep with various drifts and crosscuts. The character of the ore mined was largely sulphide with a siliceous gangue. The other important producers of milling ore were the Manhattan Dexter, Verde, Mustang, Seyler-Humphrey, Union Amalgamated, and Big Four properties. The placer properties producing were the Bulldog, Edith, Auction, Thursday Fraction, African, and China.

Northumberland Canyon district.—This district, in which the Blue Bell mine is situated, is 30 miles north of Belmont. The property was a producer of silver ore in the early seventies and again in 1917.

Oak Springs district.—The nearest railroad point is Indian Springs, from which a small quantity of copper ore containing a little silver was shipped to the smelter from the Horseshoe claim.

Reveille district.—Nine producers reported the production of 416 tons of ore, containing $417 in gold, 7,427 ounces of silver, 4,874 pounds of copper, and 233,300 pounds of lead, valued in all at $27,932, or an average value per ton of $67.14. The principal producer was the Southwestern Nevada Mines Co., which shipped oxidized lead ores containing silver and a little gold.

Round Mountain district.—Nine producers reported 13,584 tons of ore against the output of eight operators producing 29,927 tons of ore in 1916. The total output, including the production of three placers, consisted of gold, silver, and a little lead, valued at $269,635. The placer bullion contained $154,323 in gold and 4,548 ounces of silver, against a production in 1916 of $103,806 in gold and 3,121 ounces of silver. The property of the Round Mountain Mining Co. was the principal producer of gold ore and of placer gold. Bullion was also recovered from ore mined from the Fairview and Blue Jacket mines. The Seevers property yielded some oxidized lead ore and silver ore, which was shipped to the smelter. Most of the placer gold was recovered from erosion material from Round Mountain, and some gold was recovered by drift mining and sluicing the material from the Eureka claim, situated on Shoshone Creek, 3 miles from Round Mountain. The Kaurohat property,[1] in Jefferson Canyon, was reported to have its 150-ton mill in good condition by replacing its stamp batteries with ball mills and equipping the rest of the plant for treating the ore by cyanidation and oil flotation.

With a number of improvements inaugurated at the Round Mountain Co.'s[2] holdings in 1917, the production of gold was increased, according to the following extracts from its annual report:

> * * * 12,118.29 tons of ore, having a gross value of $87,366.21, were mined and milled, yielding $78,483.83 in bullion, representing an extraction of 89.8 per cent of the gross value of the ore. Figures per ton are as follows: Gross value, $7.209; tailings loss, $0.733, and net recovery, $6.476. The total operating cost, exclusive of depreciation and certain overhead and administrative expenses apportioned to both lode and placer operations, was $52,834.11, of which $26,462.20 was for milling. The total operating cost per ton was $4.359, including $2.183 for milling.
>
> In addition, your company received in royalties on lode leases $1,817.27, in returns from leasing operations on the Blue Jacket group $318.68, and as miscellaneous earnings $1,987.53. The total revenue, therefore, from lode operations was $82,607.31, or $6.816 per ton, or a total lode realization, after deducting operating costs, of $29,773.20, or $2.457 per ton. * * *
>
> During the year ending December 31, 1917, 127,788 cubic yards of placer gravel were moved, yielding 10,992.69 ounces of bullion, worth $140,016.62. Total operating costs were $47,678.52. Total realization was $93,978.07, which includes $2,961.96 received in royalties from bedrock lessees. * * * The

---

[1] Min. and Sci. Press, Oct. 30, 1917, p. 590.

[2] Round Mountain Mining Co. Twelfth Ann. Rept., for year ending Dec. 31, 1917.

gross value recovered on company account represents $1.0956 per yard, the operating cost $0.373 per yard and the realization, inclusive of royalties, $0.7354 per yard. * * *

In 1917 your company cleaned 107,678 square feet of bedrock, at an average cost of $0.0699 per square foot. The gross value recovered was $15,358.36 or $0.1426 per square foot. Bedrock leasers cleaned 163,745 square feet, yielding $12,289.51, or $0.075 per square foot. Your company realized $2,961.96, or $0.0181 per square foot. * * *

The main tail race on January 1, 1918, measured 4,280.2 feet. During the year 1,269.4 feet of flume were added, 744 feet at the head and 525.4 feet at the dump end. The bottom of the flume is lined for its entire length with five longitudinal rows of 25 pound rails. * * *

The final clean-up of the main tail race was made in October, 1917, and yielded $22,899.63 in bullion, of which amount $12,613.38 was cleaned up in the usual manner and $10,286.25 was recovered from milling 165 tons of concentrates averaging $62.34 per ton. In 1916 your company's recovery from the main tail race was $9,026.70 from 175,477 yards, the gross value of which was $139,912.16, the clean-up representing 6.5 per cent of the total value recovered. In 1917 the clean-up was $22,899.63 from 127,788 yards, the gross value of which was $140,016.52, this clean-up representing 16.3 per cent of the total value recovered.

San Antone district.—From the Hudson property two kinds of ore were produced; siliceous ore was treated by cyanidation at Tonopah, and the lead ore shipped to the smelter.

Tonopah district.—

Mine production of Tonopah district, Nev., 1904–1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	21	455,140	$1,941,441	8,734,726			$7,688,891
1917	20	470,122	1,539,529	7,068,737			7,364,168
Increase or decrease, 1917		+14,982	−401,912	−1,665,989			−324,723
Total, 1904–1917		4,783,726	24,972,732	113,966,413	12,113	214,523	92,333,975

Nearly all the output in 1917 shown above, or 469,730 tons, yielded gold and silver bullion at cyanidation plants, some of which were equipped for concentration, recovering 849 tons of silver concentrate. The mill bullion contained 72,651 ounces of gold and 6,798,077 ounces of silver, and the concentrates contained 1,732.27 ounces of gold and 260,680 ounces of silver. There were only 340 tons of silver ore shipped from the district. The average bullion recovery per ton of ore cyanided was valued at $15.12, and the average value of the concentrates per ton was $295.18. The principal producers of ore, named in order of production, were Tonopah Belmont, Tonopah Extension, Tonopah Mining, West End, Jim Butler, Rescue Eula, Montana Tonopah, and McNamara.

From the Tonopah Belmont mine[1] there were produced during the fiscal year 162,051 wet tons of crude ore, from which 27,458 wet tons of waste rock were culled. Altogether 131,100 dry tons of ore, valued at $2,170,993.93 in gold and silver, were treated by cyanidation. This ore averaged per ton 0.159 ounce of gold and 16.86 ounces of silver, valued at $16.56, in 1917, as compared with 0.20

---

[1] Tonopah-Belmont Development Co. Fifteenth Ann. Rept., for year ending Feb. 28, 1918.

ounce of gold and 19.70 ounces of silver, valued at $17.54, in 1916. Dividends paid by the company in 1917 amounted to $375,009.39, making a total of $9,518,063.32 since June 21, 1906. The annual printed report of the company gives the following information:

The total metals recovered from the Belmont mine ores were 19,953 ounces of gold and 1,946,757 ounces of silver. The entire gold production was sold at $20.5534 per ounce. The entire production of silver was sold, as produced, at an average price of 84.13 cents per ounce.

During the latter half of the year a contract for the purchase and treatment of the mine production of the Tonopah Mining Co. of Nevada was executed. With this extra tonnage, in addition to the available tonnage from the Jim Butler Tonopah Mining Co., which had previously been treated at Millers, the economy of treating all the ores at the Tonopah mill became apparent. Equipment for the handling of the foreign ore from railroad cars to the mill was installed and on December 1 the Jim Butler ores were diverted to the Tonopah mill, and since January 1, 1918, the Tonopah Mining Co.'s ores have been received at this plant. During the last quarter 15,040 dry tons of outside ores have been treated, at a profit of $3,889.94.

The royalties from the leases on the slimes ponds at Tonopah have amounted to $7,026.45.

The slimes re-treatment or "sweepings" plant at Tonopah began its second operating season on April 16, 1917, and was operated steadily and successfully throughout the "sweeping" season, or until November 14, 1917, with a net profit of $18,278.97.

The Millers cyanide mill was operated continuously during the first nine months of the fiscal year, and in this time handled 31,462 tons of custom ore, with a resulting profit of $44,952.86, including a miscellaneous profit of $364.40. Royalties from the leases on the slimes ponds at Millers amounted to $1,851.26 in addition to the above. Because the available tonnage of custom ore was insufficient to allow of the most economical operating cost, the mill was shut down—the last ore being received on November 27, 1917—and the plant was cleaned up. A considerable part of the machinery has been sold and shipped to plants of the Belmont Co.'s subsidiaries, and the mill will be further dismantled. * * *

During the fiscal year 1917–18 the Tonopah mill treated 146,140 dry tons of ore of a total metal content of 23,647.557 ounces of gold and 2,320,945.67 ounces of silver and an average metal content of 0.162 ounce of gold and 15.88 ounces of silver. The metals recovered in bullion, concentrates, etc., aggregated 22,547.126 ounces of gold and 2,170,518.92 ounces of silver. The extraction was 95.35 per cent of the gold and 93.52 per cent of the silver, or a combined extraction of 94.05 per cent—0.7 per cent higher than in the previous year.

Custom ore to the amount of 15,040 tons was purchased and treated, the recovered metals from these aggregating 2,593.64 ounecs of gold and 223,761.92 ounces of silver.

The average direct milling cost per ton of ore was $2.863, or $0.315 higher than for the previous year. The average indirect milling cost was $0.218 per ton, or $0.008 higher than for the previous year. The total milling cost per ton of $3.081 is higher by $0.323, or 11.71 per cent, than in the previous year. The advanced costs of supplies and labor account for the difference. The milling cost of producing 1 ounce of Dore bullion advanced from $0.1492 in 1916–17 to $0.2062 in 1917–18, or 38.2 per cent. * * *

The plant for the re-treatment of "sweepings" from the slimes tailings ponds, built in 1916, commenced its second season's operations on April 16, 1917, and during the summer's campaign, until November 14, 1917, the plant operated steadily, treating 5,492 tons of sweepings. The plant was cleaned up at the close of the campaign, leaving it clean of absorptions. * * *

It is of interest to note that, during the 11 years of life of the Millers plant, it handled 568,345 tons of ore, of a gross value of $11,989,512.56, and that since August, 1912, operated as a custom mill, the plant handled 341,542 tons of ore, from which a profit of $180,906.03 was derived.

The royalties accruing from the leases on the slimes tailings ponds at Tonopah and Millers during the year have amounted to $8,860.85. The profitable operations of these "sweeping" leases on the ponds is due, in great part, to the re-treatment plant at Tonopah, which has reduced the expense of shipping and marketing the material and made possible the gathering of lower grade sweepings.

The Tonopah Mining Co.[1] reports that the most successful saving in its history was accomplished in the cyanidation mill in 1917. There were milled 109,835 dry tons of ore, averaging 0.163 ounce of gold and 14.19 ounces of silver per ton, yielding bullion containing 16,929 ounces of gold and 1,443,368 ounces of silver. This represents a recovery of 94.6 per cent of the gold and 92.6 per cent of the silver, or an average recovery of 91.9 per cent of both metals and a net gain over the previous year of 1.8 per cent. Relative to some of the mill difficulties, the company report says:

> In May a Monarch reverberatory furnace was installed to take the place of the six Faber de Feuer furnaces for melting the precipitate. The reason for making the change was that the graphite retorts used in the Faber de Feuer furnaces had advanced in price from $14 to $46 each, and delivery was very uncertain. With the Monarch furnace it was possible to reduce the amount of fluxes used by approximately 50 per cent, and the graphite retorts were eliminated. The installation thus paid for itself in a very few months. Some difficulty was experienced in using over again the carborundum lining furnished with the furnace. This has been overcome by the substitution of graphite for carborundum, the graphite being reclaimed by grinding up the old retorts, from which a still further saving resulted.
>
> In September, owing to the rise in silver, it was deemed advisable to put on three shifts at the mill and increase tonnage by milling ore-house reject in conjunction with mine ore. Due to the ore-house reject, consisting chiefly of porphyry, it is very difficult to settle. Also, when it reaches the filters, it makes a very sticky, impervious cake, and decreases the capacity of the filters. For this reason it has not been possible to mill as large a tonnage of mine and ore-house reject together as mine ore alone. With the aim in view to increase the tonnage, one of the agitators is being converted into a settler, and the size of the filter leaves has been increased, where the dimensions of the filter box will permit. In addition, the dump ore, ton for ton, occupies about 10 per cent more space than the mine ore, which further limits tonnage, as volume is a determining factor throughout the process.

The West End mine[2] produced 45,910 tons of ore, valued at $721,936.91, or an average of $15.73 in gold and silver. The ore contained 7,160.93 ounces of gold and 677,116.83 ounces of silver. Dividends paid to stockholders amounted to $89,424 in 1917. At the cyanidation mill, custom ore was treated beside that from the West End mine. The direct cost of mining in 1917 was $5.21 per ton, against $4.38 in 1916, and the direct milling cost $2.79, against $2.92. The following paragraphs are taken from the company's report:

> The increased cost is distributed through practically every item, this being due to the increase in the cost of all supplies used, and also to the fact that a further increase in miners' wages took place during the year. The increase of cost as indicated by these figures is not fairly representative of the increase in the cost of supplies and labor, as old stocks of material which were purchased during the days of lower prices, were used during a portion of the year. Therefore, the outlook is for higher cost per ton in the future, rather than a decrease. * * *
>
> During the year the mill treated 66,833 dry tons of ore, an average of 183 tons per day, with a value of $20.51 per ton, this being the maximum capacity at which the plant can be operated efficiently with this grade of ore. * * *
>
> There was a daily average of 26.6 stamps dropping continuously, crushing 6.9 tons per stamp. This average is a little low due to the extreme hardness of the ore from the Ohio workings. The so-called rhodonite ore from this territory is more rebellious than from other sections of the mine, requiring finer grinding and slightly different treatment. * * *
>
> The average recovery was 94.56 per cent of the gold and 92.67 per cent of the silver, as compared to 94.5 per cent gold and 91.19 per cent silver for the pre-

---

[1] Tonopah Mining Co. of Nevada Sixteenth Ann. Rept., for year ending Dec. 31, 1917.

[2] West End Consolidated Mining Co. Eleventh Ann. Rept., for year ending Dec. 31, 1917.

vious year. The recovery of values based on net smelter returns was 91.6 per cent as compared with 90.6 per cent for the previous year. * * *.

During the past year the tonnage of custom ore from outside districts increased to such an extent that it became necessary in December to construct an additional 50-ton ore bin, so as to receive ore direct from railroad cars or auto trucks. * * *

During the month of April an entirely new vein was discovered in a raise from the 500-foot level, and a few weeks later pay ore was encountered. The vein was found in the California claim, lying in or adjacent to Mizpah trachyte.

* * *

Like all productive veins in this portion of the district the ore bodies in this vein are irregular in shape and contain here and there blocks of low-grade ore and waste. * * *

Mizpah trachyte and West End rhyolite, the two most productive ore-bearing formations of the Tonopah district, have been proved to exist in large masses in this portion of your holdings, a location which up to a year ago was believed to be composed mainly of the intrusive lavas and volcanic débris from Mount Brougher. The fact that these formations have been encountered at this point, and that a productive vein, the existence of which has been hitherto unknown, has been discovered, indicates the possibility that further prospecting of your ground in this vicinity may result in other valuable discoveries.

The Tonopah Extension Co.[1] reports the mining and milling of 110,187.7 dry tons of ore, containing 1,296,999.43 ounces of silver (averaging 11.771 ounces per ton) and 12,848.863 ounces of gold (averaging 0.117 ounce per ton). The average price received for silver was $0.86081 per ounce and $20.6718 per ounce for the gold, making the average gross value of the ore mined and milled $12.543, of which $10.133 was silver and $2.410 was gold. The gold and silver loss in tailing was $1.19 per ton of ore treated, thus making the metal recovery 90.51 per cent, or $11.353 per ton. With these deductions, there were sold 1,169,671.15 ounces of silver and 11,809.042 ounces of gold, valued in all at $1,250,982.73. The mining cost (including all development work) was $5.26 per ton; milling, $3.21; metal losses in tailing, $1.19; freight, express, and refining, $0.17; or a total cost of $9.831 per ton, and a total profit per ton of $2.712.

The Jim Butler mine[2] produced in its fiscal year 40,297 dry tons of ore, of which 443 tons were mined and milled by the West End Consolidated from undisputed Butler territory, and the remainder was treated in the Belmont mill. Since 1913 the Jim Butler has produced 189,222 tons of ore, containing 54,039.9 ounces of gold and 4,835,639.26 ounces of silver, valued in all at $4,035,283.56, with a net realization of $1,528,868.73, representing a profit of 38 per cent. The company report contains the following concerning the 1917 production:

The total production of the property, including ores from leased ground, was 55,643 wet tons of crude ore, from which there was sorted out as waste 15,529 wet tons (26.5 per cent), leaving 42,149 wet tons containing 4.4 per cent moisture, or 40,297 dry tons of mill ore, the gross metal content of which was 11,616.95 ounces of gold and 1,017,745.80 ounces of silver, and the gross value of which was $1,052,600.67. The tonnage of crude ore mined during the period was greater by 1,735 tons than the tonnage of the previous year, but because of the greater quantity of waste sorted out the tonnage of dry mill ore was less by 6,192 tons.

The total operating costs were $11.94 per ton, an increase of $1.14 per ton over the similar costs ($10.80 per ton) of the preceding year. Mining costs were $5.17 per ton, as compared with $4.80 during the preceding year, the increase being almost entirely due to advanced rates of wages. Treatment charges were $5.33 per ton, as compared with $4.79 in 1916, the higher rates being entirely due to the higher costs of mill labor and supplies. General expense, including administration, taxes, bullion taxes, insurance, etc., was 73 cents per ton, an increase of 35 cents over the 38 cents per ton cost of 1916. Losses in tailings and metal losses (smelter deduction on sales of concentrates) were $1.79 per ton, an increase of 23 cents per ton over the similar losses in 1916. This increase in losses, however, was due entirely to the higher money value of the ore milled, there having been an actual decrease of losses of 1.04 per cent. The total costs and losses were $13.73 per ton for the year, an increase of $1.57 per ton over the total costs and losses of 1916. The percentage of profit, however, was 45.42 per cent, as compared with 36.27 per cent of the previous year.

---

[1] Tonopah Extension Mining Co. Ann. Rept. for year ending Mar. 31, 1918.
[2] Jim Butler Tonopah Mining Co. Ann. Rept. for year ending Sept. 30, 1917.

Tybo district.—The entire year of 1917 was spent in equipping, dewatering, and putting the old working of the Tybo property in condition for operation. The mine is opened to depth of 400 feet by a shaft and has 3,500 feet of drifts. The 75-ton concentration plant at the mine was nearly completed in 1917. During these operations there was an important tonnage of sulphide lead ore, containing silver and gold, shipped directly to the smelter.

Union district.—Old tailings from the silver mills were re-treated by cyanidation and resulted in the recovery of silver bullion containing a little gold. A lessee on the Webster property succeeded in shipping a small quantity of silver ore, containing a little lead and gold. The principal operations on this property consisted of prospecting with a churn drill to find new ore bodies.

Willow Creek district.—One shipper of gold ore reported production in 1917.

ORMSBY COUNTY.

One deep-mine producer reported 37 tons of ore, which is 70 tons less than was produced in 1916 from 3 mines. The total average value per ton increased from $6.46 in 1916 to $41.73 in 1917, and the gold and silver value from $6.15 to $39.05 per ton.

Voltaire district.—The Panama Canal property, yielding both oxidized and sulphide ores, was a producer of ore containing silver, gold, and a little copper. The property is opened by two adits, one 400 feet and the other 375 feet.

STOREY COUNTY.

Mine production in Storey County, Nev., in 1916–1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	24	63,187	$483,137	285,827	903	11,057	$672,196
1917	33	59,805	360,875	243,072			561,166
Decrease, 1917		3,382	122,262	42,755	903	11,057	111,030

The output of ore was 3,382 tons less than in 1916, and the total average value per ton, all of which was for gold and silver, decreased from $10.64 in 1916 to $9.38 in 1917. The entire county output came from Comstock district.

Comstock district.—Thirty-three producers reported an output of 59,805 tons of ore, containing $360,875 in gold, 243,072 ounces of silver, valued in all at $561,166, or an average value per ton of $9.38.

The principal part of the ore produced was milled at cyanide plants, where there were 49,640 tons of ore treated, yielding 15,582.64 ounces of gold, valued at $322,122, and 226,213 ounces of silver. There were also 170 tons of concentrate produced at these plants valued at $30,627, or an average value per ton of $180.15. Only 80 tons of ore, containing gold and silver, were shipped to the smelters from the district, having an average value per ton of $275.23. In 1916 there were 24 producers with a total output valued at $672,196, or an average value per ton of $10.64. The principal producers in 1917 were the Union Consolidated, Chollar & Potosi, Andes Silver, Consolidated Virginia, Silver Hill, Crown Point-Belcher-Jacket, Mexican, and Ophir Silver properties. A considerable quantity of old tailings, which originated in this district, was treated at Dayton by cyanidation. The old tailing of Comstock ores on the site of mills formerly situated 5 miles below Dayton, on Carson River, have been repeatedly tested in an attempt to extract the gold and silver profitably. In September, 1917, the Dayton Placer Recovery Corporation started a new cyanidation mill equipped with six tanks holding 1,200 tons of pulp, four Dorr agitators, and two Oliver filters. About 125 tons of tailing were treated daily, with reports of good recovery.

WASHOE COUNTY.

The output of ore by 31 producers aggregated 2,820 tons, 2,241 tons less than was produced by 28 producers in 1916. The total average value per ton increased from $25.68 in 1916 to $26.21 in 1917, and the gold and silver value in the ore from $14.19 to $16.15. The greater part of the ore was milled and yielded lead concentrate, containing silver, and having an average value per ton of $168.41. Ore treated at gold and silver mills, 341 tons, produced gold and silver bullion containing $9,698 in gold and 235 ounces of silver, with an average value per ton of $29.01. The placer output amounted to $120 in gold and 2 ounces of silver.

Eagle and Washoe Valley districts.—The Washoe claim, which is situated about 3 miles west of Carson City, was the principal producer. It is reported that the ore exposed will average $11 in gold, silver, and copper per ton, which is of too low a grade to ship without concentration.

Leadville district.—Lead ore produced from the Tohoqua property and treated in its 75-ton concentration mill yielded concentrates containing lead and silver and a small quantity of gold. Another small output of lead concentrate was reported by a lessee who sluiced some of the old tailing.

Peavine district.—A small quantity of copper ore was shipped to the smelter from the Nixon-Nevada property,[1] situated 14 miles north of Reno, and a test lot of ore came from the National Copper claim. A small quantity of ore was shipped from the Gillespie tunnel, and one lot of lead ore from the Wedekind property.

White Horse district.—From various sources, 333 tons of ore were reported, all of which, with the exception of 2 tons shipped directly to the smelter, was milled in the small gold and silver plants in the district equipped principally for amalgamation. The total district output contained $9,642 in gold and 179 ounces of silver, valued in all at $9,790. The total value of the output in 1916 was $32,895.

---

[1] A newspaper report, probably issued by brokers, states that from the Nixon-Nevada "last summer (1917) 17 carloads of ore were shipped that averaged 25 per cent of copper and $15 in gold and silver as extracted from vein No. 4 at a depth of about 155 feet." This may have referred to 17 mine cars instead of railroad cars.

WHITE PINE COUNTY.

Mine production in White Pine County, Nev., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	41	4,056,257	$743,049	147,110	93,107,945	1,641,066	24,494	$23,860,917
1917	47	4,474,253	769,833	186,574	93,786,328	2,437,908	....	26,736,898
Increase or decrease, 1917	......	+417,996	+26,784	+39,464	+678,383	+796,842	−24,494	+2,875,981

[a] Includes placer production.

Two properties produce the greater part of the county output. Altogether 44 operators reported the production of 4,474,253 tons of ore, or 417,996 tons more than was produced in 1916, as reported by 40 operators. The total average value per ton increased from $5.88 in 1916 to $5.98 in 1917, but the gold and silver value in the ore was 21 cents, the same as in 1916. The bulk of the ore, 4,385,232 tons, was treated at concentration mills and yielded 595,162 tons of concentrates, nearly all of which, 594,898 tons, was copper concentrate. There were 254 tons of lead concentrate and 10 tons of silver concentrate. The total average value per ton of all concentrates was $41.07. There were 88,724 tons of ore directly smelted, which contained $32,685 in gold, 66,446 ounces of silver, 7,396,671 pounds of copper, and 2,110,132 pounds of lead, valued in all at $2,288,199, or an average value per ton of $25.79. There were 48 tons of old tailings and slag smelted, yielding gold, silver, copper, and lead. Gold and silver bullion was produced from 16 tons of ore treated at milling plants. The placer output amounted to $1,212 in gold and 10 ounces of silver, against an output reported in 1916 of $696 in gold and 7 ounces of silver.

Aurum district.—The principal output was from the Lucky Deposit property, which produced copper ore containing some silver. This ore is hauled to Currie, situated on the Nevada Northern Railway. There was also copper ore shipped from the Muncy Creek property, and oxidized lead ore from the Dandy claim situated in the Red Hills, near Aurum.

Cherry Creek district.—Tailings from an old concentrating mill 7 miles north of Cherry Creek were re-treated in a 50-ton flotation plant completed in 1917. These tailing were reground in a Hardinge mill and the valuable minerals separated in Callow flotation cells. The concentrate contained principally silver with a little gold and copper. There was also a small output of lead ore from the Gray Eagle claim.

Duck Creek district.—Seven producers reported the production of 155 tons of ore of shipping grade, containing $493 in gold, 2,088 ounces of silver, 255 pounds of copper, and 104,501 pounds of lead, valued in all at $11,271, or an average value per ton of $72.72. The principal producers were the Cuba, Lead King, McGill, Success, and White Cloud properties.

Eagle district.—The Red Hills property was operated during the year and produced lead ore containing silver and gold.

Granite district.—Four operators in the district reported 29 tons of ore containing gold, silver, and lead, and having a total value of $2,482.

Hunter district.—The Vulcan Mining, Smelting & Refining Co., owning the Hunter claims, shipped product containing principally lead, copper, and silver.

Osceola district.—The output of 3 placers consisted of $1,212 in gold and 10 ounces of silver obtained from sluicing the gravel in the Osceola town gulch.

Pinto district.—A small quantity of lead ore carrying silver was shipped from the Washington and Mareland property.

Robinson (Ely) district.—There were 16 producers in 1917, but the bulk of the ore came from two mines, the Nevada Consolidated and the Consolidated Coppermines. The following table gives a comparison of the production for the last two years and the total output beginning with the year 1904:

Mine production of Robinson district, White Pine County, Nev., 1904–1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	8	4,053,950	$737,964	110,802	93,044,578	92,127		$23,706,195
1917	16	4,467,709	765,376	131,825	93,627,420	512,862		26,478,391
Increase. 1917		413,759	27,412	21,023	582,842	420,735		2,772,196
Total, 1904–1917		28,201,817	4,652,117	846,425	644,940,304	2,006,334	42,651	120,029,665

Ore extraction at the Nevada Consolidated mine[1] aggregated 3,076,285 tons of sulphide ore, containing 1.28 per cent or copper, from the steam shovel pits, and 991,164 tons of sulphide ore, containing 2.01 per cent of copper, from the Ruth mine. In addition to the sulphide ore, there were 59,176 tons of siliceous carbonate ore, averaging 2.84 per cent of copper, 49,108 tons of which were received at the smelter at Steptoe, Nev., and 10,068 tons shipped to Garfield, Utah. The company's report contains the following detail:

> The net reserves of developed ore remaining in the Copper Flat and Ruth mines at the close of 1917 totaled 70,025,322 tons, containing an average of 1.58 per cent of copper. * * *
>
> There are other bodies of sulphide and carbonate ore of superior grade totaling more than 1,000,000 tons which have not been heretofore or now included in the regular calculated reserves. It is believed that further development will keep pace with ore extractions for some time to come.
>
> The production for the company's mines for the year showed a decrease of over 8,000,000 pounds, or about 9 per cent, as compared to the year 1916. This is due primarily to two causes—first, that the grade of ore was lower than that for previous year; and, second, that there was treated at the company's concentrator and smelter during the year a considerable tonnage of ores and concentrates from adjoining properties now owned by the Nevada Consolidated Co. The total tonnage from both sources treated at the concentrator for the year exceeded that for 1916 by some 300,000 tons. The total copper contents

---

[1] Nevada Consolidated Copper Co. Eleventh Ann. Rept., for year ending Dec. 31, 1917.

in concentrates produced at the concentrator was substantially the same for both years, but at the smelter the output of copper for the year 1917 exceeded that for the year 1916 by approximately 1,000,000 pounds. The total charge smelted exceeded that for the year 1916 by approximately 100,000 tons, equivalent to over 15 per cent. The grade of concentrates was, however, lower than that for 1916, due to the grade of ore milled being somewhat lower. * * *

The net profits for the year were $9,408,892.72, as against $15,435,359.14 for the year 1916. * * *

Distribution to stockholders during the year amounted to $8,297,746.55. The total of such disbursements from the beginning of operations up to the end of 1917 has been $35,771,603.10. * * *

Total steam-shovel mining costs of concentrating ores for the year were 33.38 cents per dry ton, of which 14.48 cents were taxes, leaving direct operating costs, including all overhead expenses other than taxes, of 18.9 cents per ton as against 12.42 cents direct operating costs for 1916. Exclusive of taxes the corresponding shovel pit mining costs in 1917 increased 52.2 per cent above the year previous. To this mining cost must be added 30 cents per dry ton of ore covering retirement of stripping suspense account. The total mining costs, including taxes and stripping suspense charge of 30 cents, amounted in 1917 to 63.38 cents, as against 53.7 cents for the previous year.

In 1917 overburden removal costs were 34.43 cents per cubic yard, as compared with 30.09 cents for 1916.

Ruth underground mining costs were $1.0251 per dry ton as compared with $1.2021 for 1916. In this mining cost is included 19.99 cents per ton covering taxes, leaving a direct mining cost of 82.52 cents as compared with $1.062 for 1916. To this mining cost must be added the development suspense charge of 30 cents per dry ton and deferred construction charge of 5 cents, making total mining cost, including taxes, $1.3751. The reduction in mining cost here as compared to that of 1916 was due in part to increased tonnage and in part to employing wholly a more economical system of mining than was first used. * * *

The total sulphide ore tonnage milled during 1917 was 4,064,095 tons averaging 1.462 per cent copper, with an actual mill extraction of 73.08 per cent, ratio of concentration 7.18 to 1, and average copper in concentrates 7.673 per cent, the ratio of concentration and grade of concentrates being somewhat lower than during the year previous owing in part to the large percentage of the ore milled being of primary character, relatively high in iron and sulphur contents.

The Consolidated Coppermines Co.[1] in 1917 produced 9,806,898 pounds of copper, at an average selling price of 24.57 cents per pound, 11,979 ounces of silver, 2,557.10 ounces of gold, and 65,309 pounds of lead, valued in all at $2,473,438.85. From the company's annual report the following paragraphs are taken:

Your company owns in fee 1,151 acres of mining properties and claims, together with 2,565 acres of ranch lands having valuable water rights. It also controls, through ownership of approximately 99 per cent of the capital stock of Giroux Consolidated Mines Co., 2,000 acres of patented mining claims, and 1,800 acres of ranch lands, which also have valuable water rights; also, through its stock ownership in the Butte & Ely Co., 209 acres of patented mining claims. The total area of properties owned and controlled by the Coppermines Co. is 3,360 acres of patented mining claims and 4,365 acres of ranch lands.

The most notable development of the period has been the opening up of the high-grade oxidized ores in the Alpha mine. This work has been productive of most excellent results. The ore has been found at various points extending from the 800 to the 1,200 foot levels, and the ore shoots are proving to be larger and more continuous on the lower levels, with the grade continuing at about 8 per cent. * * *

It has been found that three classes of copper ore occur in the properties, (1) sulphide concentrating ore, occurring in large continuous masses of monzonite porphyry; (2) direct smelting oxidized ore, forming replacement deposits in limestone in the vicinity of limestone-porphyry contacts; and (3) direct smelting sulphide ore, with high iron contents. Our underground development work has been confined to the Morris-Brooks mine, where concentrating porphyry ore occurs, and the Alpha, which produces direct smelting oxidized ore. * * *

---

[1] Consolidated Coppermines Co. Ann. Rept. for year ending Apr. 30, 1918.

In making the estimates of ore reserves herewith submitted, certain tonnages of low-grade porphyry ore have not been included which were taken into account in previous reports. On this revised basis it is estimated that there is concentrating porphyry sulphide ore, wholly or partly developed, amounting to 20,092,800 tons, averaging 1.31 per cent copper. In addition there are considerable tonnages of direct smelting ores, both oxidized and sulphides, although development work is not sufficiently advanced to permit of their accurate calculation.

Ore was mined at three different points: (1) The Morris-Brooks mine, supplying ore to our Kimberly concentrator; (2) the Alpha mine, producing direct smelting ores only; and (3) the Liberty Pit, where ore is mined by steam shovel by the Nevada Consolidated Copper Co. and concentrated at its Steptoe Reduction Works for our account.

The tonnage mined, grade of ore, and metals produced were as follows:

	Dry tons mined.	Copper.	Copper produced.	Silver produced.	Gold produced.
		Per cent.	*Pounds.*	*Ounces.*	*Ounces.*
Morris-Brook	144,204	1.69	3,320,727	3,287.29	1,505.440
Alpha	22,958	8.62	3,753,662	965.88	59.030
Liberty Pit	175,958	1.36	2,726,863	2,758.19	980.783
	343,120	....	9,801,252	7,031.36	2,545.253

A small amount of ore was also mined by leasers, the total being 257.5 tons, which yielded 5,646 pounds of copper, 4,947.72 ounces of silver, 11.848 ounces of gold, and 65,309 pounds of lead. * * *

The remodeling of the old Kimberly concentrator, which had been begun in 1916, was completed and the mill put into operation in the early spring of 1917. The first unit gave satisfactory results and it was decided to install a second unit, bringing the capacity up to 1,000 tons per day. As the water supply is obtained from the Alpha mine, it is necessary to conserve its use as far as possible, and to this end three Dorr thickeners to dewater the mill tailings were installed and completed late last year. Considerable delay was experienced in securing delivery of equipment and completing all this work, but at the date of this report both units are in full operation.

Concentrating results for the year at our Kimberly concentrator were as follows: Tons ore milled, 145,466; tons concentrates produced, 11,883; ratio of concentration, 12.2 into 1; grade of ore, 1.69 per cent copper; grade of concentrates, 15.07 per cent copper; and percentage of recovery, 73.0 per cent.

Results of concentrating our ores at the Steptoe works were as follows: Tons ore milled, 174,056; tons concentrates produced, 17,199; ratio of concentration, 10.12 into 1; grade of ore, 1.36 per cent copper; grade of concentrates, 8.21 per cent copper; and percentage of recovery, 59.86 per cent.

Taylor or Ward district.—From two properties there were produced 3,580 tons of ore. The old Ward mine, known in the early days as the Paymaster, was the principal producer, shipping to the smelter oxidized lead ore containing silver. This property is opened by an adit 2,500 feet long. The Argus claim produced a small quantity of silver ore containing copper and lead.

White Pine district.—In 1917 there were produced 1,225 tons of ore, valued at $97,434, or an average value per ton of $79.54, reported by five producers. About half of the ore was milled, and yielded 205 tons of concentrates, containing 11.32 ounces of gold, 6,285 ounces of silver, and 257,631 pounds of lead. The ore of shipping grade (610 tons) contained 13.25 ounces of gold, 13,938 ounces of silver, 3,838 pounds of copper, and 663,458 pounds of lead. The Nevada, Young Treasure, and Jennie A. properties were the principal producers.

SECONDARY METALS.

By J. P. DUNLOP.

INTRODUCTION.

SCOPE OF REPORT.

"Secondary metals" are those recovered from scrap metal, sweepings, skimmings, and drosses, and are so called to distinguish them from the metals derived directly from ores, which are termed "primary metals." The distinction does not imply that secondary metals are of inferior quality, for metals derived whether from ore or from waste material vary in purity and in adaptability for use in making certain products. The reports to the United States Geological Survey now include the secondary recoveries of copper, zinc, lead, tin, antimony, aluminum, and nickel. The figures obtained by the Survey are given as a supplement to the regular reports on primary metals in order to enable producers and consumers to form a more comprehensive idea of the quantities of metal available for consumption; in fact, they constitute an essential addition to the seven general reports on primary metals, though only a part of the recovery of waste metals is given.

RECOVERY OF WASTE MATERIAL.

NEED OF CONSERVING WASTE MATERIAL.

Never before in the United States has the need for the utilization of waste material been so urgent. Trade journals and daily newspapers are continually hammering into the public mind the economic changes that not only force conservation in the consumption of food, metals, clothing, and other commodities, but that also require the prompt recovery and putting back into trade channels of all material that can be reused. Not only must waste material be utilized but, on account of the ever-increasing scarcity of labor, methods must be adopted which will lessen the labor required to place waste materials where they can be used. Large corporations long ago recognized the great importance of properly segregating every kind of waste, and war conditions causing a rapid advance in the cost of labor, materials, and freight brought many recruits to conservation from the ranks of the smaller manufacturers and merchants. Shop and store methods had to be modified to meet changed conditions. It is the nonbusiness class, the great body of consuming householders who lack the stimulus of any substantial monetary reward but who can give the extra shove that will bring the recovery of waste to the peak. Practically all persons have aided the Government by saving food and have also deprived themselves of comforts or pleasures to buy bonds. To segregate properly and to see that all waste reaches a place where it can be used entails no discomfort and very little expense. Most waste material sells for higher prices than ever before, but the small amount of money that can be obtained for the junk of an ordinary household or farm is not an incentive that appeals to many persons. An incentive that does appeal, however, is the fact that the Nation requires and must have service, and nothing can be substituted for it.

Nearly everyone knows that paper, wool, iron, and tin are scarce; that nonessential industries are daily finding it more difficult to obtain materials; and that even some absolutely essential industries can not obtain all the supplies they require. Natural resources are strained to the limit to provide raw material, and many demands go unsatisfied. The quantity of metal and other scrap from most dwellings, yards, stores, or farms appears insignificant, but "many a mickle makes a muckle," and the accumulation from millions of sources will amount to hundreds of thousands of tons. A small quantity of mixed material in the home or yard is merely dirt, misplaced matter, useless and usually unsightly. Sort and send that same material to a place where it becomes part of large piles and it becomes potential wealth for the community and for the Nation. It is the patriotic duty of every municipality and every individual promptly to market every bit of junk. War demands men and money; it also demands some materials in huge quantities, which will not be forthcoming unless the primary sources of production are supplemented by close recoveries from secondary sources through voluntary personal effort. Plans have been made, which are now being perfected, for the recovery of foil and collapsible tubes made wholly or partly from tin. Through an advertising campaign, through notices on the packages, and by other methods, consumers of articles are urged to save the containers and to send them to the nearest Red Cross center to be sold to dealers and smelters.

BRITISH SYSTEM OF SALVAGE.

The Waste Trade Journal, of August 3, 1918, contains the following remarks of Otto H. Kahn, of Kuhn, Loeb & Co., New York, on the salvage system adopted by the British Army:

> As a business man, I was naturally able to realize best their organization for the business side of war. They have drafted their best business brains everywhere into the service of the Government. Their supply, transportation, manufacturing, and salvage systems, for instance, are marvels of business organization.
>
> Andrew Weir, director general of supplies and, among other things, in charge of the Army salvage system, was good enough to show and explain to me his methods of operation. He told me that in the space of three years he will have saved to the nation through salvage, or, rather, in effect created for the nation, $500,000,000 out of things which formerly went into the scrap heap.
>
> Our Army is engaged in similar work, though it has not yet, of course, attained the magnitude of the British. If we find ways of applying after the war systematically in civil life the lessons now being learned as to the use and value of materials heretofore considered absolute waste, the possibility of the creation of wealth by that means in our country almost staggers the imagination.

ARMY RECLAMATION DIVISION.

The United States Army, through the Quartermaster Corps, has established a reclamation division which supervises the collection, sorting, and shipment of all wastes that accumulate at cantonments, and a special training camp is to be established at Jacksonville, Fla., to train officers to supervise this essential work in France, as well as at cantonments and Army depots and warehouses in the United States. Drafted men who have business knowledge of various wastes and who are not deemed capable of active service in the field will be assigned to this service.

ECONOMIES EFFECTED BY THE NAVY DEPARTMENT.

The annual report of the United States Navy Department[1] for the year 1917 shows that it does not lag behind in readjustments to meet business conditions:

140. The manufacture of open-hearth steel by the use of cheap unsalable scrap has been further developed, effecting considerable saving over the ordinary practice of using practically all the heavy and higher priced melting stock.

141. Notwithstanding the recent increases in the market value of pig iron the cost of liquid steel from the open-hearth furnace has remained practically the same on account of the use of cheap steel scrap, which up until this time had to be sold at prices which amounted to a loss of money to the Government.

142. Metallurgical practices brought into effect in the bronze and brass foundry during the fiscal year 1916 have been continued with steady improvements. The immense accumulation of scrap metals which existed two years ago has been very materially reduced, and in many instances it is now necessary to resort to the use of new metals on account of the scarcity of scrap metals.

143. On account of the scarcity of red bronze and composition scrap consistent efforts have been made to increase the use of naval brass and manganese bronze by making a study of the various castings and the substitution of these cheaper grades of materials, for which the present supply of scrap is still more than adequate to meet all of the demands of the foundry for metals, and the use of manganese bronze during the past year has increased from approximately 188,000 pounds to 363,000 pounds per annum, and of naval brass from 320,000 pounds to 637,000 pounds per annum, while the use of red bronze and composition has been decreased from 908,000 pounds per annum to 734,000 pounds per annum.

144. In order to utilize the large accumulation of yellow brass scrap resulting from the manufacture of cartridge cases the manufacture of naval brass forging ingots has been further extended, until at the present time practically all the requirements on the forge shop for bronze torpedo forgings are being met by the use of forging ingots manufactured at the gun factory.

145. The recent heavy demand for small-caliber cartridge cases and the existence of a surplus of lower grade cartridge-case scrap has made possible the development of the manufacture of cartridge-case slabs in the crucible furnaces in the new experimental plant established under the metallurgical and testing division, which has resulted in a considerable saving to the Government. In this operation crop ends and dirty scrap resulting from the manufacture of large-caliber cartridge cases, which were formerly considered unsuitable for further use in cartridge-case manufacture, have been melted in natural-draft crucible furnaces, and after careful treatment to free the material from foreign matter poured into slabs, which have been used with entire success in the manufacture of 1-pounder and 3-pounder cartridge cases, all of which up to the present time passed proof test satisfactorily.

146. Operations of the smelting plant at the gun factory have continued with the same satisfactory results as reported during the previous year. Immense quantities of lower grade scrap materials have been reclaimed in the

---

[1] U. S. Navy Dept. Ann. Rept., pp. 234–236, 1917.

form of usable ingot material for the production of casting and forging ingots, which has resulted in holding the cost of the gun-factory output of nonferrous casting below the regular market price for similar castings made by outside manufacturers, notwithstanding the increased market value of all nonferrous metals.

147. During the past year there has been produced in the smelting plant at the gun factory from scrap metals a total of 1,704,405 pounds of casting ingots, consisting of manganese bronze, 703,852 pounds; naval brass, 468,588 pounds; and phosphor bronze or composition, 531,965 pounds.

148. Based on the average market value of ingot material of similar characteristics compared with the cost of production of the above ingot material at the gun factory, the operation of the smelting plant has, during the past year, saved the Government approximately $308,775, which amount would have been absolutely lost to the Government had this scrap been sold or given to contractors on reworking contracts. With the installation and equipping of the new smelting plant, and the operation of the electric furnace for scrap recovery, it is believed that it will be possible to make still further progress in the reclaiming of scrap materials such as light yellow brass-scrap, manganese bronze turnings, etc., which will effect considerable additional saving to the Government.

149. A large increase in both buildings and machinery to care for the greatly increased output necessary for the war has been recommended, and the plans are underway so that when funds are available the work will proceed rapidly. The great advantage to the Navy of this large plant has been shown in hundreds of ways since the mobilization of the fleet.

SCRAP-IRON DEALERS.

Owing to the enormous demand for iron and steel and the shortage of scrap metal it is becoming difficult to abtain adequate supplies for war needs. Users of iron and steel who do not get priority allocations are eagerly seeking supplies, and every effort is being made to increase the supply of scrap, especially since it has become necessary to prohibit shipments to blast furnaces of certain grades of scrap which can be utilized by rolling mills.

The subcommittee on scrap iron and steel of the American Iron and Steel Institute, through its chairman, W. Vernon Phillips, Pennsylvania building, Philadelphia, has issued the following letter to members of the American Board of Scrap Iron Dealers:

> At the request of the director of steel supplies of the War Industries Board, the chairman of this committee is addressing all members of your board, asking them to cooperate with the Government for the purpose of locating and reporting to this office all lots of unprepared scrap which are being withheld from the market, principally in the form of obsolete railways, old mine heads and tipples which are not being operated, unused bridges, or similar structures, old manufacturing plants not in operation, contractor's equipment and similar material which should be shipped to scrap yards for preparation.
>
> Please have not only your office but your correspondents in various parts of the country report with as full particulars as possible, endeavoring in every case to get the name of the owner, court or trustee having charge.
>
> Please report all instances on a sheet of the size and in the form prescribed herewith, in order that we may tabulate them properly. (Sheet is 8½ by 11 inches, ordinary letterhead size.)
>
> We are also inclosing a list of questions which please answer for the guidance of the Government in determining the present shortage or condition of scrap.

1. Location of material____
2. Estimated tonnage____
3. Form and character of material______________________________
4. Name of owners, trustees of such information as you can procure__________
5. Availability of shipment. State whether on railroad or if necessary to use other means of transportation__________________________________
6. Name of nearest railroad___________________________________
7. Distance from nearest scrap yard_____________________________
8. Name of nearest scrap yard_________________________________
9. Other information____

(Name and address of party reporting.)

Other questions asked of dealers, to gain an idea of tonnage available from yards are as follows:

1. How much scrap of all sorts you have on hand at the present time (irrespective of the amount sold, not including any material en route). (Make separate report for each yard.)
2. How much scrap had you on hand June 1, 1917. (Figures should represent as nearly as possible the total tonnage on all grades of iron and steel irrespective of the amount sold and should not include any material en route.)
3. Are you operating your plant to its fullest capacity.

(Name and address of party reporting.)

Throughout the United States, especially in those districts which include many plants working on rush war work, scrap yards and machine shops are being searched for tools, machinery, engines, and boilers which have been scrapped. Much of this discarded material has been reconstructed because it was possible, by replacing worn out parts, to put the articles to serviceable use where it was impossible to obtain new articles for prompt or for near future delivery.

There has been a larger and more extended use of scrap metals by foundries. Sometimes this increased use was due to the high cost of some new metals, but more frequently it was caused by the inability to obtain prompt delivery of new metal. Most foundries have used some scrap; those making small and cheap castings frequently used no new pig metals. In other foundries which specialized in castings made to strict specifications the experimental use of scrap metal had resulted in defective castings because the scrap had not been used to advantage.

It is an essential help to be able to recognize the approximate composition from the shape of a scrap casting, for such knowledge facilitates sorting. There are very few alloys that can not be made to carry some scrap to advantage by a judicious system of proportioning, and many foundries and manufacturing plants driven to experiment by necessity have become successful users of scrap metals.

There has also been a further extension of the facilities for segregating and recovering metal from scrap, drosses, ashes, and skimmings, and more efficient methods are adopted for decreasing melting losses and for the removal of deleterious substances. The use of magnetic separators for the removal of iron from nonferrous scrap, the installation of crushers, jigs, and tables for the recovery of metal from ashes, sand, grindings, and sweepings have become more common. Large users of metals, instead of selling scrap, drosses and other wastes, send the carefully segregated material to smelting plants, where it is refined on toll and returned for reuse. Clippings and light, thin-gage scrap of known analysis is cabbaged before being remelted. Many manufacturing plants accumulate large quantities of light chips, curls, or needles, which have an enormous surface area when compared with an equal weight of the same alloy or metal in ingot form. To avoid the excessive melting losses which occur when such material is remelted in crucibles, it has been necessary to briquet this kind of scrap at the plant or ship it to a smelter or refinery for treatment.

In 1917 a large quantity of light chips, curls, and needles was treated by the Eastern Brass & Ingot Corporation at its plants in Waterbury, Conn., and Chicago, Ill. This corporation does not sell, lease, or install equipment; it treats material by the Duryea process of making solid ingots and charges for the service rendered on a sliding scale, according to the quantity of material shipped to it. It is stated that the cost of the plant, the necessity of expert supervision, and the large quantity of scrap required to maintain continuous operation prevent the Duryea process from being economically used at individual manufacturing plants. At both the Waterbury and Chicago plants each shipment is kept separate. The metal or alloy is thoroughly cleaned and all free iron removed. The cleaned material is then made into ingots ranging from 3 to 3½ inches in diameter and from 1½ to 2 inches in thickness, and weighing from 3 to 5 pounds. These ingots and all waste and dirt, equaling in weight the material received, are returned to the shipper. No heat is used and no binder; the ingots are made by combining enormous pressures with a sharp shock in such a manner as to expel the air before the shock is delivered. The expulsion of the air prevents the ingot being blown apart when charged into a crucible, and the ingot made is so dense that when sawed the even, clean exposed surface indicates that the particles of metal have flowed together. The advantages claimed for the conversion of light waste into briquet ingots include a saving in the labor of handling and in loss of metal, owing to the fact that the briquet ingots are round and so solid that they may be forked, dumped, and handled without appreciable loss by abrasion; a saving in crucibles because their shape and density of the ingots enable a maximum weight charge; a greater output at less cost for fuel and for time required in melting; a better product; and a reduction of about 80 per cent in losses by oxidation.

SOURCES OF INFORMATION.

The Geological Survey frequently receives letters inquiring as to the treatment of drosses and skimmings of alloys suitable for certain products and making other technical inquiries which it is not able to answer, though it endeavors to indicate where such information may be obtained. There are many trade papers and journals which give the source and nature of waste material and the prevailing prices of all kinds of scrap metals. They also contain replies to many questions relating to remelting, refining, and proper methods of alloying.

There never has been a time when it was so necessary for every business man to keep in touch with conditions and regulations which directly or indirectly affect his business. The daily newspapers can not possibly give adequate space to specific data relating to varied industries, nor are they competent to analyze or even correctly state the causes and results of freight embargoes, allocation of supplies, priorities, price fixations, export and import licenses, and other restrictions which are vital to the metal and other trades.

To keep in touch with the daily changes of the business world every manufacturer using metals and every buyer, seller, and broker of metals should receive some or all of the daily trade papers. Many of these papers, such as the American Metal Market, Daily Metal Reporter, and Daily Iron Trade and Metal Market Report, have special representatives at Washington and in other places who promptly report and comment upon all matters that affect metals and products made from metal. In addition to the trade papers issued daily, everyone interested in metals should obtain the more comprehensive and technical information given in weekly or monthly trade journals, such as the Waste Trade Journal, the Metal Industry, the Brass World, Foundry, the Iron Age, and the Iron Trade Review.

The Geological Survey, in common with other Government agencies, has willingly replied to many inquiries for information, which has been widely and promptly disseminated by trade papers and the technical press. An increased circulation of the trade papers and journals will increase the knowledge of the subscribers, and, to some extent, diminish the burden imposed on the technical and statistical force of the Government engaged in the more important and necessary research connected with the war.

WARRING ON WASTE.[1]

By **William Crawford Hirsch.** [Editor, Waste Trade Journal.]

MAKING THE SCRAP PILE AN ASSET.

One of the reasons the scrap pile is neglected by most factory managers is the misconception caused by applying to it the common term "junk heap." "Junk" to most of them means "worthless." This, however, is far from the truth, as the scrap pile can be made not only an asset, if well managed, but an analysis of what goes into it is also a good indicator of the solidity of the business.

For a telltale whether an industrial establishment is well managed or whether its solidity is being undermined by carelessness, the scrap heap seeks its equal. It is more symptomatic of the health or decline of a manufacturing plant than mercantile agency reports or bank references. To the astute industrial engineer it is what a patient's tongue is to a physician, enabling him to detect the seat and nature of the ailment.

Odds and ends of plates and sheets strewn about the scrap heap of an automobile plant when they might be worked up into washers are usually an infallible sign that something is wrong. No less indicative of a careless attitude is a pell-mell accumulation of iron, steel, and nonferrous metal scrap which, while awaiting a buyer, is permitted to deteriorate in value by exposure.

Perhaps not a little of the indifference in the attitude of many plant officials toward scrap is to be attributed to a misconception of the word, which in their minds has become associated with something that is useless.

There could, however, be no more fallacious notion, for the very latest machinery contains in its vitals iron and steel regenerated from scrap, and the copper in its bearings may in a previous state have done service in a kettle. To scrap is vouchsafed the return to metal as useful as that of virgin origin—provided, of course, proper care is taken of the scrap.

For much in the way of strips, cuttings, and clippings that result from the working up of sheet steel, tinplate and terneplate, copper, brass, lead or zinc sheets, a more profitable outlet can be found than the scrap heap. Considerable of this material can be sold to manufacturers of specialties whose products call for small sizes of sheet metals, such as, for instance, bottle caps. Such remnants are to be considered as scrap only when no market can be found for them otherwise.

The scrap heap should comprise nothing except metal which must be remelted to give it any value. To this injunction may be added the admonition that the scrap heap should exist only as a figure of speech. It should never be a heap, but kept as orderly and tidy as the most valuable of new material.

The dollar and cents value of order and punctilious care in the handling of scrap is illustrated perhaps best by the difference in the market value of borings and turnings properly separated and those sold as a mixture. The maximum price fixed by the War Industries Board of the Council of National Defense for cast-iron borings is $20 a gross ton. The same level was established for machine-shop turnings. In most of the large consuming scrap-iron markets these grades have virtually attained the maximum value permitted under the regulations. When borings and turnings are mixed, they command $3 a gross ton less.

---

[1] Factory, April, 1918.

HOW SCRAP MAY BE INCREASED IN VALUE.

By judicious organization of its scrap conservation system the average industrial plant can add considerable value to its scrap, although the final grading to make the material available for conversion must be done by the scrap dealer, for the simple reason that very few individual plants produce sufficient quantities to make this possible.

Moreover, in the case of assorting any scrap intended for consumption by steel mills, intricate specifications have to be complied with. To observe these, even though the necessary equipment, such as large shears and hydraulic presses, were available, would be unprofitable for the occasional shipper of scrap, as the work of grading calls for highly trained though not skilled labor.

One steel company excludes from its scrap purchases all pieces weighing less than 5 pounds per linear foot, while the weight limit with others ranges from 10 to 300 pounds. Weights are limited by the mechanical means of the individual consumer for handling material. The minimum weight is prescribed so as to prevent the shipping to the steel mill of too light material, which makes for excessive oxidation.

The charging boxes of the various furnaces differ, and some mills will not accept any piece of scrap that deviates in the slightest degree from the straight shape, because crooked pieces do not fit snugly into the charging boxes.

Up to the present, specifications of the various scrap-iron consuming mills vary considerably. Eventually these will be standardized, and the scrap producer will be the gainer by such a procedure fully as much as the consumer.

HOW SCRAP IS CLASSIFIED AND GRADED.

Railroads, whence emanates the largest amount of iron and steel scrap, follow, as a rule, the official specifications of the Railway Storekeepers' Association. The class of iron and steel scrap sold by the railroads differs, however, from that produced in industrial plants, and the specifications of the steel mills and foundries owe their complicated provisions chiefly to the great diversity of material found in industrial scrap.

The most important grade of scrap consumed by steel mills is known as No. 1 heavy melting steel. For this grade the Carnegie Steel Co. exacts compliance with the following qualitative specification:

> Must be one-fourth inch and over in thickness, nothing to exceed 6 feet in length, free from pipe busheling. All scrap from industrial steel. Railroad scrap in charging-box size will be acceptable under these specifications, to be free from cast iron, malleable iron, or any other foreign substance.

Many mills accept wrought scrap as heavy melting steel. Industrial plants, however, are most prolific in the production of cast-iron scrap.

WHAT IS THE BEST GRADE OF CAST-IRON SCRAP.

A model specification for the leading grade of cast-iron scrap, known as No. 1 machinery cast, is that ratified by the American Foundrymen's Association, which reads as follows:

> This material shall consist of cast-iron scrap of first quality which possesses evidence of having been machined, such as planed or turned surfaces, bored or drilled holes, or similar markings. It must be cupola size, no piece to weigh more than 100 pounds, and must not exceed 24 inches in length or width; No. 1 heavy pieces greater than 1 inch in section, No. 1 medium pieces one-half inch and not to exceed 1 inch in section, No. 1 light pieces not to exceed one-half inch in section. Scrap classified as railroad cast scrap, or under any other classification, will not be accepted under this classification.

Cast scrap, such as columns, pipes, plates, and rough castings, comes under the head of rough cast with appropriate subclassifications. A special classification is provided for burnt machinery scrap, which is known as No. 5.

Stove plate forms another important scrap grade used by the foundries. It is commonly understood to consist of broken cast-iron stoves, but must be free from all burnt parts, grates, and from malleable iron and steel parts as well. Broken radiators make up a separate scrap-iron classification.

Malleable cast scrap consists of material that has undergone the annealing process. Malleable cast-iron parts of automobiles form a grade by themselves, while miscellaneous malleable scrap consists of valves, flanges, and pipe fittings of every description.

HOW LIGHT METAL SCRAP MAY BE HANDLED.

In addition to the heavy scrap consumed by the open-hearth steel furnaces, the bulk of which comes from the railroads, they use large quantities of light steel scrap which is made up from steel springs, turnings, drillings, and borings from wrought iron and mild steel, tires, and bundled sheet scrap. Bundled sheet scrap consists of new side or end clippings and shearings which are securely bundled with wire to permit their being handled with a magnet without falling to pieces. Many firms have balers which they use for this. The amount of this light material made at a plant in a year will decide whether a baler is a profitable investment. To be handled economically sheet scrap must be baled. It is then possible to load cars to maximum weight and so help in the conservation of cars. For this many firms find it profitable to install their own baler.

Especial care should be taken to prevent rust or corrosion which would make all such scrap undesirable.

Stub ends of carbon tools, carbon-steel saw plates, wearing plates, steel horseshoes, horseshoe nails, steel buckles, steel snaps and clamps, and small soft steel castings come under the classification of crucible steel scrap.

IMPORTANCE OF STORAGE FOR WASTE.

In conclusion, it may be stated that unless proper provisions are made for the systematized collection and storage of all waste material, the best intentions will prove unavailing. For nonferrous metals the best plan in the average factory is to have compartment boxes, properly labeled and conveniently stationed for the various departments.

According to the plant's requirements separate boxes or compartments can be set aside for copper, brass, zinc, lead, and tin. There should also be a box for rubber. Preferably these boxes should have sufficient capacity so that when filled they indicate that enough material has accumulated to warrant disposal in worth-while quantities.

For the heavier scrap there must be ample space set aside in the factory grounds. If very heavy scrap is produced, it will be most advantageous to have the scrap storage space as convenient to a railroad siding as possible. The allotted space should be properly subdivided into sections, each one of which is set aside for a special grade or kind of scrap, according to individual requirements.

HOW THE SCRAP PILE MAY BE TURNED INTO AN ASSET.

Properly managed, the equipment provided for the conservation of scrap and the time and effort expended in its systematic accumulation, supervision, and disposal will prove not only directly profitable but the indirect return which will come from the enhanced care that will be accorded new material is certain to prove of incalculable value. Many plants have found this true soon after they began to dig beneath the surface of their scrap heap. As stated at the beginning of this article, there is perhaps no more reliable index to the state of an industrial enterprise than the manner in which its scrap is handled, stored, and converted to use.

CLASSIFICATION FOR OLD METALS.

The National Association of Waste Material Dealers has succeeded in remedying many trade abuses, and the metal division of the organization has grown until it includes practically every leading dealer in scrap metals and drosses. It has a grievance committee of three members to whom all disputes between members are referred. If this committee is unable to adjust a dispute it recommends arbitration. There have been disputes, but all have been adjusted, usually without an arbitration committee, and so far no member has entered suit against a fellow member. There are several sections forming the association, of which the scrap-metal section is by far the strongest and most efficient.

The classification for old metals adopted by the association is receiving more recognition every year from manufacturers, foundrymen, and other users of metals.

The following standard of classification for old metals has been adopted by the National Association of Waste Material Dealers to be effective from July 1, 1918 to July 1, 1919, at which date a new circular will be issued. Dealers or consumers wishing to have these circulars mailed to them as they are issued, should forward their request direct to the secretary, Charles M. Haskins, 185 Summer Street, Boston, Mass.

1. Delivery: (*a*) Delivery of more or less on the specified quantity up to 2½ per cent is permissible.

(*b*) If the term "about" is used, it is understood that 5 per cent more or less of the quantity may be delivered.

(*c*) Should the seller fail to make deliveries as specified in the contract the purchaser has the option of cancelling all of the uncompleted deliveries or holding the seller for whatever damages the purchaser may sustain through failure to deliver and if unable to agree on the amount of damages, the arbitration committee of the National Association of Waste Material Dealers, appointed for this purpose, to determine the amount of such damages.

(*d*) In the event that buyer should claim the goods delivered on a contract are not up to the proper standard, and the seller claims that they are a proper delivery, the dispute shall be referred to the arbitration committee of the National Association of Waste Material Dealers, to be appointed for that purpose.

(*e*) A contract for a carload, unless otherwise agreed upon, shall mean the minimum quantity recognized by the official classification tariff of the district in which the seller is located.

(*f*) A ton shall be understood to be 2,000 pounds, unless otherwise specified.

(*g*) If, through embargo, a delivery can not be made at the time specified, the contract shall remain valid, and shall be completed immediately on the lifting of the embargo, and terms of said contract shall not be changed.

2. Heavy copper: This shall consist of copper not less than $\frac{1}{16}$ inch thick, and may include trolley wire, heavy field wire, heavy armature wire, that is not tangled, and also new copper clippings and punchings, untinned and clean, and copper segments that are clean.

3. No. 1 copper wire: To consist of clean untinned copper wire not smaller than No. 16 B. & S. wire gage to be free from burnt copper wire which is brittle and all foreign substances.

4. No. 2 copper wire: To consist of miscellaneous clean copper wire such as of necessity would be taken out of the heavy copper and the No. 1 copper wire, but to be free of hair wire and burnt wire which is brittle.

5. Light copper shall consist of the bottoms of kettles and boilers, bath tub linings, hair wire, burnt copper wire which is brittle, roofing copper, and similar copper, free from radiators, brass, lead and solder connections, readily removable iron, old electrotype shells and free of excessive paint, tar, and scale.

6. Composition or red brass shall consist of red scrap brass, valves, machinery bearings, and other parts of machinery, including miscellaneous castings made of copper, tin, zinc, and/or lead, no piece to measure more than 12 inches over any one part, to be free of aluminum and manganese, also free of railroad boxes, cocks and faucets, gates, pot pieces, ingots, and burned brass.

7. Railroad bearing shall consist of railroad boxes or car journal bearings, must be old standard used scrap, free of yellow boxes, plastic and similar bearings, also iron-packed boxes, and must be free of babbitt; also free of excessive grease and dirt.

8. Cocks and faucets: To be mixed red and yellow, free of gas cocks and beer faucets; shall be at least half red.

9. Heavy yellow brass shall consist of heavy brass castings, rolled brass, rod brass ends, brass screws, and tinned or nickel-plated brass tubing; to be free of iron and dirt and must be in pieces not too large for crucibles; no piece to measure more than 12 inches over any one part. Must also be free of aluminum and manganese mixtures. Condenser tubes shall not be considered as heavy brass.

10. Light brass shall consist of light sheet brass, forks and spoons, miscellaneous brass that is too light for heavy, to be free of any visible iron, radiators, gun shells containing paper, ashes or iron, loaded lamp bases and clock works.

11. New brass clippings shall consist of the cuttings of new sheet brass to be absolutely clean and free from any foreign substances.

12. Brass tubing shall consist of brass tubing, free of nickel plating, tinned, soldered, or tubes with cast brass connections. To be sound, clean tubes, free of sediment and condenser tubes.

13. No. 1 composition turnings: To be free of aluminum, manganese, plastic, and yellow brass turnings, not to contain over 2 per cent iron, to be free of grindings or foreign material, especially babbitt, and free from adulterations made to resemble metal. Turnings not according to this specification subject to sample.

14. No. 1 yellow brass turnings shall consist of strictly rod turnings, free of aluminum, manganese, composition, and tobin turnings. Not to contain over 3 per cent of iron, oil, or other moisture, to be free of grindings and babbitts. To avoid dispute, to be sold subject to sample.

15. No. 1 pewter shall consist of tableware and soda fountain boxes, but in any case must test 84 per cent tin. Siphon tops to be treated for separately.

16. Auto radiators: To be classed separately, must be free from iron.

17. Zinc must consist of clean sheet and cast zinc, also cast batteries to be free of loose oxide and dross, salammoniac cans, and other foreign materials.

18. Tin foil shall consist of pure foil, free of lead compositions and other foreign ingredients and matters.

19. Electrotype shells must be hand picked and free of dross.

20. Battery and lead plates shall consist of battery lead plates, free of wood, rubber, and paper.

21. New sheet aluminum clippings shall consist of new sheet aluminum and cuttings. Must be free from oil, grease, and any other foreign substances. Must be guaranteed not less than 98 per cent pure aluminum.

22. Aluminum wire shall consist of aluminum wire guaranteed 98 to 99 per cent pure aluminum, and must be free from corrosion and any other foreign substance.

23. Painted sheet aluminum shall consist of painted sheet aluminum and must be absolutely free from iron, dirt, or any other foreign substance.

24. Aluminum castings shall consist of aluminum castings, free from iron, babbitt, brass, and any other foreign substance. Must not exceed 2 per cent of oil and grease.

25. Old sheet aluminum shall consist of old and manufactured sheet aluminum. Must be free from painted sheet aluminum, iron, dirt, and any other foreign substance.

26. Aluminum borings, to avoid dispute, should be sold subject to sample.

27. Aluminum foil shall consist of pure aluminum foil, free from paper and any foreign ingredients.

28. Babbitt metal shall contain bearing metal of all kinds. Shall not contain scrap hard metal, Allen metal (which is copper and lead alloy) die cast, zinc boxes, or type metal.

29. Packages shall be good strong packages, suitable for shipment, and each package to be plainly marked with the gross and tare weights so that when packages reach their destination, their weights can be easily checked.

When goods are not packed according to the above specifications and the shipper wants his rejections returned, the cost of labor shall be charged to the shipper.

REVIEW OF THE SECONDARY METALS IN INDUSTRY IN 1917.

Dealers in and refiners and smelters of scrap metals continued to do a large business in 1917, though it is doubtful if the business done was as profitable or as large as in 1916. Stocks of some new metals, such as copper, tin, and aluminum, were small and spot shipments were not always available. On the other hand, there were ample supplies of zinc and antimony and prices for these metals decreased. Generally there was an active demand for nearly all scrap metals throughout the year. Profits were less because prices were fixed during the year for certain metals and expenses were greater on account of higher costs of labor. Freight embargoes, restrictions of various kinds, and changing business conditions hampered the secondary metal trade. The active demand for scrap metals stimulated the collection of scrap metal from all sources, but the increased quantity of waste material was due mainly to the vast extension of industries connected with material for war purposes. The increase was confined mostly to clean new scrap, as the scarcity of labor and supplies and the clearly defined policy of the Government restricting construction of new buildings for nonessential purposes lessened the quantity of old metal derived from the demolition of structures which under ordinary conditions would have been replaced by new buildings and equipment. A smaller quantity of zinc was used for galvanizing, consequently less zinc dross was available for redistillation or remelting, and of this reduced output a considerable part was exported to Europe for treatment.

More scrap metals were sold directly from the producer to foundries, and there were fewer resales between dealers and brokers. One result of the fixed price of aluminum is that considerable quantities of scrap aluminum and aluminum alloy are purchased directly by consumers from the producers at prices which secondary smelters and refiners making ingot can not afford to pay. New pig aluminum is barely sufficient in quantity to satisfy the requirements of priority consumers, so that the stocks available for nonessential industries are negligible. If the consumers are purchasing only heavy scrap, the losses in remelting, though large, are not serious; but if large quantities of clippings, borings, and grindings are used by foundries, there is a very large loss in remelting, which would be avoided if the light scrap went to the large refineries that specialize in the treatment of such wastes.

Part of the metal or metals contained in drosses and skimmings undoubtedly is recovered and reused several times in one year. Similar conditions prevail in the use of all junk or waste material. New clean scrap is sold and becomes mixed with old scrap contained in articles that have been used and discarded. New clean clippings of zinc, tin, and aluminum are usually carefully segregated from other scrap metals, but many dealers in metals, or smelters, do not keep separate records of other new clean scrap and old used metals. The quantity of the various metals contained in numerous alloys made partly or wholly from secondary material can not be definitely ascertained. The figures given as the result of the inquiry made by the Geological Survey are only approximate, but they are the only available data of an important industry.

Provost Marshal General Crowder has ruled that persons employed in scrap iron and steel yards are engaged in a useful occupation, and it is expected that priority rights for fuel, labor, and supplies will be granted to the scrap-metal industry, which is not only essential but is one requiring skilled and experienced labor to treat, sort, and ship its varied products properly.

The value of the secondary metals, exclusive of gold, silver, platinum, iron, steel, and ferroalloys, recovered in the United States increased from $265,377,856 in 1916 to $295,854,900 in 1917. The increase was due partly to larger use of copper and copper alloys and partly to much higher average price of aluminum, tin, and alloys containing tin.

The value of the secondary platinum, iridium, and palladium recovered in 1917 amounted to about $6,650,000, and the value of old jewelry, dental waste, silver spoons, ornaments, and other material containing gold or silver, remelted and refined, was probably more than $25,000,000. It is difficult to estimate the value of ferrous scrap remelted in 1917. Estimates of the quantity vary from 12,000,000 to 15,000,000 long tons, and the value from $400,000,000 to $450,000,000. Some of the scrap ferrous metal contained nickel, tungsten, manganese, chromium, vanadium, or other alloys, which made it many times more valuable than the more ordinary commercial products, though the market is limited and some knowledge is necessary to locate prospective purchasers. Old rails, car wheels, pipe, and other iron and steel shapes, were often sold at prices in excess of the original cost. Iron and steel scrap is used by all foundries and rolling mills, and hundreds of thousands of tons of it are collected, sorted, and shipped.

A number of railways having revenues insufficient to cover expenses were sold to dealers in junk. The prices paid for such railways were large, although as operating concerns the railways were worthless to the owners of their stocks and bonds. In some cases attempts were made to abrogate such sales, and injunctions were applied for on the ground that the scrapping of the railways would deprive the territory served by it of all transportation by rail.

One of the anomalies with reference both to scrap copper and to scrap iron and steel was that when maximum prices of virgin primary metal were promulgated the unusual demand would and did to a small extent result in the scrapping of virgin material. The danger was removed by establishing fixed prices for copper, iron, and steel scrap. Scrap-metal dealers and refiners think that though it is proper to insist on rigid specifications requiring the use of the highest-grade virgin metals in making some of the articles required by the Army and the Navy, nevertheless such specifications could be so modified for other requirements as to permit the use of lower-grade material. Such modifications would result in saving considerable money as well as in expediting deliveries.

It is impracticable and unnecessary to segregate the statistics relating to the melting, refining, and using of secondary metals according to States, but more than 90 per cent of the refining and smelting of drosses and scrap metals in the United States is confined to the territory east of St. Louis and north of Ohio River.

Nearly all the secondary aluminum was reported from the States of Ohio, Michigan, Illinois, Wisconsin, and Connecticut.

The largest recoveries from tin dross, tin scruff, and clean tin scrap were made in Pennsylvania, New York, and New Jersey. Nearly all the secondary nickel was reported from Connecticut, the recoveries of lead, zinc, and copper, and of such alloys as babbitt, bronze, brass, and pewter, were more generally distributed.

SECONDARY METALS RECOVERED.

Secondary metals recovered in the United States in 1916 and 1917.

	1916		1917	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Secondary copper, including that in alloys other than brass	140,000	$68,880,000	159,400	$87,032,400
Remelted brass	300,000	127,440,000	320,000	141,888,000
Secondary lead	56,700	13,289,400	45,100	16,082,000
Recovered lead in alloys	39,600		48,400	
Secondary spelter	50,700	14,284,400	31,400	7,384,800
Recovered zinc in alloys other than brass	2,600		4,800	
Secondary tin	7,600	15,131,040	6,000	23,920,200
Recovered tin in alloys	9,800		13,400	
Secondary antimony	80	2,270,016	3	2,061,700
Recovered antimony in alloys	4,400		4,955	
Secondary aluminum	12,900	23,430,200	6,660	16,711,800
Recovered aluminum in alloys	6,400		9,440	
Secondary nickel[a]	16	652,800	60	774,000
Recovered nickel in alloys[a]	800		800	
	....	265,377,856	....	295,854,900

[a] Recoveries made by International Nickel Co. from scrap nickel or alloys and from nickel in scrap ferrous alloys from any source are not included.

SECONDARY COPPER.

The total quantity of secondary copper recovered in 1917, on the assumption that the brass remelted had an average copper content of 70 per cent, was 383,400 short tons, of which 39,558 tons (12,654 tons less than in 1916) was recovered by plants refining primary metals and the remainder by plants treating only secondary materials. The copper produced by smelters of the latter class includes 88,426 tons of pig copper, 31,340 tons of copper in alloys other than brass, and 224,000 tons of copper in remelted brass. These figures indicate an increase for 1917 of about 14,300 tons of pig copper, 14,400 tons of copper in brass, and about 17,300 tons in alloys other than brass. At least 188,500 tons was recovered from clean scrap made in the course of manufacture of copper and brass ware, so that less than 195,000 tons was obtained from ashes, cinders, and scrap, or from material that had actually been used and discarded. From the reports received it is quite evident that there was an increase in the quantity of old scrap brass and copper smelted, and that there was a very large proportionate increase in the quantity of clean new scrap remelted. The reports from munition factories show enormous increase in the quantity of clean scrap remelted, and apparently there was a decrease in the quantity of scrap brass from other users. The quantity of scrap brass used amounted to 320,000 tons, and of this at least 205,000 tons was clean new punchings, filings, and clippings.

The value of the copper, both as metal and in alloys, is computed at the average yearly price of 27.3 cents, the average sales price of all marketable grades of new metal. This average sales price for 1917 includes the price for the latter part of the year, when a fixed price supplanted open market quotations.

According to the Bureau of Foreign and Domestic Commerce the exports for the calendar year 1917 of scrap brass and copper, fit only for remanufacture, were 4,149 tons of scrap brass and 535 tons of scrap copper, and the imports of scrap copper were 8,934 and of scrap brass 28,035 tons. Many railways sell or turn in the larger portion of their brass and copper scrap and other metal waste to dealers in part payment for new material, but the reports received show that the railways utilized in their own shops and foundries more than 18,820 tons of brass, in addition to 950 tons of copper and 1,120 tons of copper in alloys other than brass. The railway reports, however, frequently include alloys termed brass which should more properly be designated as bronze. There was only a very small increase in the quantity of copper alloys used by railways in 1917.

The production of copper from secondary sources in 1917 was equal to about 31 per cent of the refinery output of primary copper in the United States from all sources, or about 41 per cent of the primary copper smelted from domestic ore.

Secondary copper recovered in 1917.

	Tons of 2,000 pounds.
Copper from scrap, drosses, etc	88,442
Copper produced from alloys other than brass	31,400
	119,842
From new scrap	45,000
From old scrap	74,842
	119,842
Brass scrap melted:	
New clean scrap	205,000
Old scrap	115,000
	320,000
Copper content of brass scrap (averaging about 70 per cent copper):	
New scrap	143,500
Old scrap	80,500
	224,000
Total copper produced at secondary plants:	
From new scrap	188,500
From old scrap	155,342
	343,842

The Daily Iron Trade and Metal Market Report, published in June, 1918, a series of articles by Charles Vickers relating to the composition, adaptability, and use of various scrap metals and drosses. Some excerpts from these articles, which are both interesting and useful, are as follows:

> *Red brass scrap.*—Composition or red brass shall consist of red brass scrap, valves, machinery bearings, and other parts of machinery, including miscellaneous castings made of copper, tin, zinc, and (or) lead, no piece to measure more than 12 inches over any one part, to be free of aluminum and manganese, also free of railroad boxes, cocks and faucets, gates, pot pieces, ingots, and burned brass.
>
> In the utilization of secondary metals, red brass scrap is high-grade material, but to use it to the best advantage it should be picked over by some one familiar

with the alloys most generally used in castings. Thus the valves should be segregated, as it is pretty certain they contain nothing that would be injurious, such as aluminum. While the composition of the valves may vary to a considerable extent, they can usually be relied upon to produce a good red metal for general castings. They can also be used in place of tin for hardening yellow brass.

In melting valves they should never be taken from the bin and be added to a bath of molten metal, as disastrous explosions have followed this practice. This action results because they may be damp inside. If all the valves it is desired to melt in a heat can not be added with the first charge, and additions must be made, they should be superheated by being placed in a sawed off old crucible, which is placed in the furnace on top of the pot that is melting the heat. When the valves get a dull red they should be removed and thrown on the floor. They can then be added to molten metal without any danger.

Machinery bearings make good scrap. The undesirable material to be looked for is highly leaded metal and phosphor bronze. Metal with a high lead content can generally be identified by fracture, but phosphor bronze will have to be melted, when it can be identified by its great fluidity. Bearings high in tin can be identified by the fracture, which is close grained and whitish. Such castings can be used in place of tin for making red brass, especially if each heat consists in part of new metal and part of red brass scrap. A judicious mixing of the high tin scrap will make unnecessary the use of any metallic tin. Even in normal times it is desirable to economize on tin because of its high cost, and the foundryman who understands his scrap pile has a tremendous advantage over his competitors in this respect and can undersell them every time.

As a general thing all scrap machinery parts of brass contains good metal. It is always advisable, however, to break off corners and examine the fractures. A reddish speckled fracture shows excessive oxidation, and the wise melter takes his precautions against porosity of product by using care in melting and adding a deoxidizer. Miscellaneous castings of red brass are not always what they seem, in these days of aluminum and manganese bronze, as it is difficult to identify these alloys when situated amongst scrap, no matter how desirous the dealer may be of removing them. They can often be identified, however, by means of an emery wheel, by grinding them hard so as to heat the metal. Manganese bronze will show greenish yellow streaks, while aluminum bronze will heat greatly, burr over at the sides, and abrade slowly. Large castings that have to be broken up are easily identified, as when red hot they are tough and can not be broken.

When all the better grade of metal has been removed from the scrap brass, the residue of doubtful composition should be used for the less important castings.

Heavy brass scrap.—The specifications for nonferrous scrap metals adopted by the National Association of Waste Material Dealers, define "heavy copper" as copper not less than one-sixteenth of an inch thick, and may include trolley wire, heavy field wire, heavy armature wire, that is not tangled, and also new copper clippings and punchings, untinned and clean, and copper segments that are clean.

Heavy copper, while requiring a little more careful handling in melting than ingot copper, to avoid undue oxidation, upon receiving this attention is fully equal to ingot for the purpose of making alloys of brass, bronze, and other metals such as babbits containing percentages of copper. It is not suitable for making electrical copper castings where conductivity is a requirement, because there is a possibility of its containing some alloying element such as silicon, phosphorus, tin, or zinc, and for the purposes of electrical conductors, high purity is essential to high conductivity.

It is possible to make high conductivity castings from heavy copper scrap by careful selection, and this is frequently done, but such material when used indiscriminately can not be relied upon for this purpose, but for the purpose of making such alloys as bronze, 88-10-2, and kindred alloys, and for composition 85, three fives, and for yellow brass, heavy copper makes excellent material.

In melting trolley wire in crucibles, the best results are obtained when it is cut into lengths of about 18 inches for melting in a No. 40 to a No. 70 pot. For larger crucibles the wire can be cut to greater lengths, as the crucible is deeper. A good way to gauge the length of the wire for any size crucible is to make it long enough for about one-third to extend above the top of the crucible when the wire is placed upright therein. When melting trolley wire a "deepener" should always be used on the crucible. This consists of the bilge cut from a worn out crucible usually, but they may be purchased new to fit any size crucible. The deepener protects the lengths of wire protruding out of the crucible from the furnace gases and prevents them melting off and falling outside the crucible.

Small blocks of hard wood should be placed in the deepener on top of the wire, to furnish a charcoal covering for the copper as it melts. The gases from the burning wood act as a protection to the heated copper.

Handled in this manner, trolley wire usually can be packed in the crucible so that the entire charge of copper can be contained therein cold. When it is not possible to get in all of the trolley wire at one time, and additions have to be made when part has first melted, it is well to adopt the precaution of warming the residue of the wire to drive off moisture that would otherwise produce little explosions when the cold wire was introduced into the bath of the melted copper. These explosions cause loss of copper as some of the molten charge is ejected. The loss can be kept down by a thick layer of charcoal, and by warming the wire. The latter should not be made so hot that it can not be easily handled by gloved hands, otherwise tongs have to be used, and much time is lost thereby.

After the wire is melted the additions of tin, zinc, and lead are made in the usual manner.

Light brass scrap.—Light brass shall consist of light sheet brass, forks and spoons, miscellaneous brass that is too light to be classified as heavy, to be free of any visible iron, gun shells containing paper, or iron loaded lamp bases, and of clock works.

Light brass consists of almost every article for which sheet brass is used, such as old lamps, bird cages, curtain trimmings, door knobs, musical instruments, gas fixtures, brass tubing, match boxes, belt buckles, pins, and ornamental brass work of every description. Light brass is full of impurities such as iron and steel, solder and nickel. For casting purposes neither nickel nor solder does any harm, as the lead and tin of the solder are usually in such proportion that the one metal imparts stiffness and the other easy machining qualities.

The iron and steel are undesirable impurities, and greatly limit the use of the material from a casting standpoint. The iron exists in the form of studs, nuts, rivets, pins, wire, springs, washers, and brass plated steel articles, the latter being especially difficult to identify when well brass plated, and it would prove too expensive to remove them individually with a magnet, and the pins, rivets, etc., are so firmly embedded that it would be hopeless to attempt their removal. The iron, therefore, has to be melted out, in which process no matter what care is used to keep the temperature of the metal as low as possible, some of the iron will be dissolved, owing to its affinity for the zinc. While some of this iron is chemically combined and does no harm in this condition, a considerable portion, because of its combination with carbon, always separates from the brass as the latter solidifies and exists as nodules scattered throughout the brass. When this material is used for castings, it is not practical to carry out much machine work on them because of the danger of striking one or more of these hard pieces of steel which would inevitably ruin the tools. Light brass, therefore, has to be used for such castings as have little finishing done on them, or that can be finished by grinding. This material is used for cheap car journal brasses, which consist of scrap yellow brass leaded to capacity, but for this purpose as for all other casting purposes it is necessary first to run the brass ingots and then remelt the ingots for the castings. By this practice the brass gets skimmed twice and this favors the removal of the iron. The loss in melting light brass runs from 15 to 22 per cent, due to the iron, the thinness of the metal, and to nonmetallic material concealed in some of the articles. The average composition of the material after being ingoted will be copper, 72 per cent; zinc, 28 per cent; allowing for loss of spelter and not considering solder and iron.

Light brass is a material entirely unfitted for making brass castings that require machining, and especially for castings finished by automatic tools. When light brass is smelted for its copper content, as is sometimes the case, all the iron, zinc, and other impurities are eliminated in the slag, but this method results in the waste of a large percentage of the material. For car journal bearings, light brass is melted in large heats into ingots, and the ingots are remelted with scrap copper bottoms and miscellaneous red scrap, and the resulting metal is treated with all the lead that it has been experimentally determined can be held in the metal without dropping to the bottom of the castings.

Yellow brass turnings.—No. 1 yellow brass turnings shall consist of strictly rod turnings, free of aluminum, manganese, composition, and tobin turnings. They shall not contain over 3 per cent of iron, oil, or other moisture, and be free of grindings and babbitts. To avoid dispute, they shall be sold subject to sample.

Brass rods are used in enormous quantities to supply automatic machines with material from which studs, pins, rivets, screws, knobs, and thousands of other small articles can be cheaply fashioned. This results in a large production of brass chips, often the weight of the chips exceeds the weight of the articles made from the rod, consequently yellow brass turnings of this description are a standard commodity of the scrap metal trade. These chips usually are leaded, as the rod from which they are made must machine freely. They will contain from 2 to 2.5 per cent of lead, and it is easy to identify leaded brass chips by their short appearance as they are finely divided, while the unleaded brass turnings will be in the form of spirals and fibrous shavings.

The composition of screw rod chips will be approximately as follows: Copper, 62 per cent; zinc, 35.75 per cent; and lead, 2.25 per cent. Oil is used in cutting brass on the automatic machine and consequently all brass chips are more or less greasy. The amount of oil should not, however, be so great that it runs off and forms pools on the floor where the chips are stored. The oil does not hurt the chips, but as it burns away the percentage of loss is higher in the case of very oily chips. As the chips are bought subject to sample, the condition of oiliness should be taken into consideration.

A considerable amount of screw-rod chips at present made come from plants engaged in munition work, and most generally contain aluminum. This element causes much trouble in foundry operations, and before purchasing chips of unknown origin in large quantity it is always a good idea to purchase a sample of about 500 pounds, which will enable a melt to be made that will be fairly representative of the material. The presence of aluminum is easily detected when the chips are melted, and when its presence is established the proper value of the chips can be determined in a way that will preclude all chance of dispute. As it costs money to eliminate the aluminum, the price should be made accordingly. All chips for foundry purposes should be melted into ingots, and the ingots used for castings. In melting chips from aluminized stock it will be necessary to incorporate an amount of copper oxide that will have to be determined by experiment. The aluminum is thus oxidized out of the turnings and the ingot produced therefrom is clean and can be used in any place where such chips are consumed. Previous to melting, the chips should be put through a magnet machine to remove the iron, otherwise the ingot brass would fail to machine properly because of the presence of hard nodules of steel.

Clean yellow brass chips can always be used to advantage in brass foundry operations. A method in vogue in some foundries is to use chips in every pot of metal melted. A certain amount of chips are placed in the bottom of the pots, probably about one-fifth of the crucible full, and the ingots are put on top of the chips, the latter forming a cushion for the ingots. The chips melt first and wash off the ends of the ingots. The zinc in the chips acts as a deoxidizer, much of it being volatilized and condensing on the surface of the ingots, thus preventing them from being oxidized as they get heated. Where this practice prevails, it has been noticed that little difficulty is ever experienced from porosity of the castings. It is always advisable in connection with the use of chips in this manner that a little salt—about a tablespoonful—be placed on top of the chips before the copper is charged on top. The chips are not weighed with the heat when used in this manner as they are measured out with a scoop which adds a certain amount by weight. The excess zinc in the yellow chips compensates for the loss by volatilization of that in the mixture, and the metal loss is thrown on the chips.

Lamp bases and clock works.—It will be noted that the specifications for light brass state they shall be free of iron-loaded lamp bases and of clock works. It follows, therefore, that these latter have to be removed from the light brass scrap, and as it would be too costly to pound them up and remove the iron they are allowed to accumulate and are sold for what they are. The iron can be removed from the lamp bases quite easily and the brass part thrown into the light brass, but the clock works are a thing separate unto themselves and have to be accorded special treatment.

Clock works have two outlets: First, as a raw material for copper smelting; and second, as a source for making yellow brass ingots. In the first outlet all the zinc is lost, which will be seen from the composition of the brass, as it is a considerable percentage of the metal. The average composition of clock brass is copper, 62.50 per cent; zinc, 35.75 per cent, and lead, 1.75 per cent. Clock works at one time were used largely in making car journal bearings of the cheap kind. They were run down at a low temperature in crucibles holding 1,000 pounds, the metal skimmed of iron and then ingoted, and the ingots melted with a percentage of copper in the form of old copper bottoms. A comparatively large amount of lead was added.

Clock works, however, make inferior and irony metal because so many of the little screws and pieces of steel springs melt and enter the brass. The best way to utilize them is to take the loss of zinc and recover the copper only. When clock works are used for the copper content they are assayed to determine their copper value. To accomplish this it is necessary to take a half bushel sample, as nearly representative of the pile of clocks as possible, and by the use of vise, hammer, and cold chisel to remove all the steel parts from the clock works. This must be carefully done and the clock works are weighed both before and after the removal of the iron parts. When clean of iron the brass is melted under borax and ingoted and the ingot analyzed for copper. By multiplying the weight of the ingot in grams by the percentage of copper found by analysis, the content of copper in the ingot is found in grams. If this figure is multiplied by 100 and divided by the weight of the brass before being melted, and after the iron has been removed, a figure is obtained that represents the percentage of copper in the clocks. On this figure, which is the copper value, is based the price of the clocks.

SECONDARY LEAD.

The secondary lead recovered in 1917 amounted to 93,500 short tons, or about 2,800 tons less than in 1916. The secondary lead recovered as pig lead increased about 11,000 tons, and the recovery of secondary pig lead made by those smelters whose product is mainly primary metal was 4,000 tons less in 1917 than it was in 1916. A portion of the recovered lead in alloys was derived from old babbitt, solder, type metal, and white metal drosses. The main sources of secondary pig lead are old pipe, lead cable, battery lead, and lead lining of acid tanks. Regular smelters reported the recovery of 4,363 tons of lead in scrap antimonial lead. It is stated that the manufacturers of toys formerly imported from Europe consume a large quantity of impure and very low-grade lead scrap.

The quantity of scrap antimonial lead remelted by regular smelters was nearly 39 per cent less than that reported in 1916.

The total output of secondary lead was equal to about 16 per cent of the refined primary lead produced in the United States in 1917, compared with 16.8 per cent in 1916. It was exceeded by the primary domestic lead output of only three States—Missouri, Idaho, and Utah—and was more than the combined quantity of primary lead derived from the ores smelted from all other States.

Some of the sources of scrap lead and the methods of remelting and using such scrap are given in the following extracts from articles prepared by Charles Vickers for the Daily Iron Trade and Metal Market Report:

Sources of scrap lead.—Scrap lead usually is found in the form of sheet lead cuttings and old lead pipe from plumbing operations. The latter comprises a varied assortment of water pipe, soil pipe, drain pipe, joints, and traps. Scrap pipe frequently contains much foreign matter and water, which adds to its weight, especially when it is kinked.

Considerable caution is necessary in melting old lead pipe because of the water it may contain. Such material should never be plunged carelessly into a bath of molten metal, as some very disastrous explosions have followed this practice, and trouble may be expected always, unless the pipe can be looked through from end to end to make sure there is no water or water absorbent material contained in it. Even when the pipe is seen to be entirely empty, it is advisable to use a certain amount of caution in adding it to melted metal. The open end of the pipe should never be turned in the direction of any person, when the other end is being introduced into melted metal, because should there be any dampness in the pipe it will cause it to act like a gun, and molten lead will be blown out of the open end.

Scrap lead should be carefully sorted as it is possible that block tin pipe may have become mixed with it. If there are any brass parts, such as ferrules, they should be cut off. The joints are also to be removed, as they consist of wiping solder, the composition of which is two parts lead and one part tin. These joints usually are removed by the scrap metal dealer, as they bring several cents more a pound than the straight pipe.

Clean scrap lead can be used in the foundry, but it is a question whether its use is much of an economy, as the price is little less than that of ingot lead. It is doubtful if there is any advantage in its use in brass castings, as the pig lead is much purer.

Scrap lead is very likely to contain antimony, and while this element is sometimes used in brass in place of tin, it can only be used in certain unimportant alloys and then with great caution. For this reason it is better to use pig lead and take no chances, especially in view of the fact that there is so little difference in price of the two kinds of material.

Antimony finds its way into lead pipe from the scrap material used by many pipe makers, and tin is also found in lead pipe. Neither of these metals harm the pipe, as they stiffen it and make it more resistant to corrosive influences, but when the pipe is used as a source of lead it is better to have it pure.

When melting scrap lead a flux of tallow or resin should be used on top of the metal to disentangle the dross from the metal. A small amount of either of these fluxes is all that is required to clear the surface of the bath. When the molten lead has become thick from dissolved oxides, a stick of green wood should be held in the bottom of the kettle and the lead should be allowed to boil from the wood. This will reduce the oxides and restore the lead to its accustomed state of fluidity.

Tea lead.—Tea lead is obtained from the linings of tea chests, and it is used for this purpose because it is the cheapest metal that could be obtained to inclose the leaves of tea and prevent access of moisture thereto, which would spoil the leaves. Tea lead usually is as pure as any grade of commercial lead. It is made from pig lead.

Tea lead loses considerably on being remelted as it is such thin metal, running from 0.005 inch in thickness, that a large surface is exposed to oxidation. Tea lead also is frequently covered on one side with paper which further increases the loss. It usually is considered that the loss in melting tea lead is from 200 to 300 pounds to the ton, or from 10 to 15 per cent. In the case of paper-covered lead, the loss will sometimes run over 18 per cent. It is advisable in melting tea lead first to have a bath of molten lead by melting pig lead, and then to plunge the sheet lead under the surface of the bath. In this manner it is melted with the minimum amount of oxidation. If the bath of lead be not too hot, the paper on the sheet lead will not be likely to cause an explosion.

Dross.—Lead always is more or less oxidized when it is melted, the extent of the change depending upon just how the temperature of the bath is regulated. A film of oxide forms on the surface of the metal and when disturbed new surfaces are exposed to oxidation. No method of preventing the formation of this dross is known, and as the lead is skimmed the dross accumulates and is finally removed from the kettle and stored for sale to smelters.

The dross is never pure oxide because considerable lead in a metallic state always is entangled therewith. An assay of lead dross generally shows a lead content nearly that of pure lead, as the oxide contains 92.82 per cent metallic lead, and it does not require much metallic lead to be mixed with it to increase this content considerably. Assays of lead dross show varying contents of lead, according to the condition of the dross, whether clean or dirty, finely divided or containing considerable spatters. The lead content varies from 95 per cent lead to 62 per cent lead, the latter dross being quite dirty.

It is possible to get most of the metallic lead out of the dross by putting it through a No. 20 screen. That which passes through the screen is largely oxide of lead, and that remaining in the screen includes spatters and shot or metallic lead. In reclaiming the lead, the oxide can be screened out of the dross, and the screenings added to a kettle half full of lead and just about red hot. The liquid lead melts and absorbs the finely divided lead, and the bath is cooled, and must be allowed to become hot again before a further addition of scrap can be made. A little tallow or rosin melted on the bath greatly facilitates separation of lead and oxide.

SECONDARY ZINC.

The output of secondary zinc (including that in brass) amounted to 116,200 tons and equaled 17 per cent of the production of primary spelter in the United States in 1917, compared with 16 per cent in 1916. The recovery was about 1,200 tons more than in 1916, and all the increase was due to the increased quantity of zinc contained in brass recovered, for the recovery from zinc dross and skimmings was much less in 1917 than in 1916.

Two smelters in New Jersey, two in New York, and one each in California and Pennsylvania, which treat only zinc drosses and skimmings, use large graphite retorts of 600 to 800 pounds capacity instead of the small clay retorts used by smelters treating ore or mixed ore and drosses. The many uses of zinc drosses and skimmings create active competition for their purchase. Considerable zinc is recovered by sweating, and the residues are sold for redistillation. Secondary spelter varies in quality just as the spelter derived from ore does, but a part of the secondary spelter is reported to be of excellent quality.

The production of spelter from drosses and skimmings made by those zinc smelters that do not treat any ore was 5,151 tons less in 1917 than in 1916. This decrease was due in part to the redistillation of the low grades of spelter in order to meet the demand for spelter suitable for brass used in making war munitions, and also in part to the larger quantity of zinc residues used for other purposes. The main reason, however, was that there was a considerable decrease in the quantity of galvanized sheets, pipes, and forms produced, so that less zinc dross was shipped by galvanizing plants and a large quantity of drosses, skimmings, and ashes were exported.

The zinc recovered in alloys other than brass amounted to 4,800 tons, compared with 2,600 tons in 1916. Of the 31,400 tons of secondary zinc recovered as spelter 16,835 tons were obtained by redistillation from drosses and skimmings. Of this quantity 8,519 tons were obtained by smelters whose principal source of zinc is ore. This was about 7,677 tons less than the recovery from drosses and skimmings in 1916. In addition to the 31,400 tons of remelted and redistilled spelter it is estimated that at least 15,000 tons of zinc chloride was made, and likewise about 64,260 tons (marketed production) of the zinc pigment lithopone (containing approximately 22 per cent zinc sulphide and oxide). The zinc used in both of the last-named products is derived largely from zinc drosses and skimmings, of which 19,154 short tons was used in addition to some zinc oxide. The exports of zinc drosses, which amounted to 2,526 tons in 1914, to 3,668 tons in 1915, to 48 tons in 1916, increased to 13,302 tons in 1917.

The urgent demand for scrap steel has resulted in establishing a new industry—that of degalvanizing old zinc-coated scrap so that the steel can be utilized. The zinc coating is removed by the niter cake process and marketed as zinc carbonate or zinc sulphate.

Secondary zinc recovered in 1917.

	Short tons.
Zinc recovered by redistillation by regular smelting plants that also treat ores	8,519
Zinc recovered by redistillation by plants that treat only secondary material	8,316
Total redistilled	16,835
Zinc recovered by remelting, sweating, etc	14,565
Total zinc recovered as spelter	31,400
Zinc recovered in alloys other than brass	4,800
Zinc recovered in brass (estimated)	80,000
Total	116,200

The quantity of zinc recovered as spelter decreased from 50,700 tons in 1916 to 31,400 tons in 1917. That obtained by redistillation from drosses, skimmings, etc., decreased from 29,663 tons to 16,835 tons.

The estimated recoveries of zinc in brass increased from 61,700 tons to 80,000 tons in 1917.

SECONDARY ANTIMONY.

The production of secondary antimony, of which all but 6 tons was recovered in alloys, increased from 4,480 short tons in 1916 to 4,961 short tons in 1917. The value assigned is arbitrary and is based on the average yearly price for ordinary brands of antimony published by the American Metal Market. The regular smelters reported the recovery of 370 tons of antimony contained in antimonial lead scrap, a decrease of 158 tons. The principal materials refined or remelted which contained antimony as an alloy were hard lead drosses, babbitt, solder, pewter, and type metal. Antimony used in the rubber, glass, enamel, paint, and ceramic industries and also for war uses does not yield any secondary recoveries. The use of antimony for shrapnel bullets, for primers, for coloring rubber, and for pigments has materially increased in the last two years. The imports in 1917 of antimony as metal in ore or as oxide or salts amounted to 17,924 short tons, and the recovery from secondary sources was equal to 28 per cent of the imports. The production of antimony from antimony and antimonial lead ores of domestic origin in 1917 was about 2,502 tons, or about one-half the quantity recovered from secondary sources.

SECONDARY TIN.

Although the United States consumes more than 50 per cent of the world's production of tin, apparently there were only a few tons of domestic tin ores smelted in the United States in 1917. Part of the tin concentrates produced in Alaska, containing about 90 tons of metallic tin, were shipped to Singapore, Federated Malay States, for treatment and the remainder was sent to New Jersey. The American Smelting & Refining Co. imported and smelted tin concentrates from Bolivia at its plant in New Jersey. Tin concentrates from Bolivia were also smelted in electric furnaces by the Andes Electin Co., of New York. The capacity of the plant on Staten

Island is being doubled. Another tin smelter which will also use Bolivian concentrates is under construction on Long Island by the Williams-Harvey Corporation.

The secondary tin recovered in 1917 was equal to about 25 per cent of the tin imported, as metal or as oxide, into the United States during the year (77,866 short tons). Secondary tin recoveries increased from 17,400 tons, valued at $15,131,040, in 1916 to 19,400 tons, valued at $23,920,200, in 1917. The quantity recovered as tin was 6,000 tons and that in alloys and chemical compounds 13,400 tons. The value of the recovered tin here assigned is arbitrary and is based on the yearly average price for new metal, 61.65 cents, given by the American Metal Market. The secondary tin in alloys increased about 3,600 tons and the secondary pig tin decreased about 1,600 tons.

Nearly all clean tin-plate scrap is detinned by one of three processes—the electrolytic alkali, the chlorine, or the alkali saltpeter.[1]

By the first method the tin is recovered in the form of a spongy granulated precipitate, which can be remelted into pig tin; by the second process tetrachloride of tin is recovered for use in silk dyeing and weighting; and by the third process the tin is recovered as an oxide, which is either used as coloring in the enamel industry or is smelted into pig tin by means of a reverberatory furnace.

The recovered tin in alloys includes the tin content of products made in several plants from clean tin-plate scrap and more than 15,500 tons of old tin cans. This included some tin oxide and putty powder but consisted mainly of tin chloride. The production of these compounds is calculated as metal and not separately stated in order to avoid disclosing confidential information. As the products are made from scrap tin and thus conserve the primary metal, they are properly regarded as recovered tin.

The largest recoveries of tin were made from the scruff and drosses that occur in making tin plate and terneplate, and amounted to more than 4,800 tons. The quantity of tinplate and terneplate made in 1917 was about 265,000 tons more than in 1916.

About 3,330 tons of tin were recovered from clean scrap tin plate, either as pig tin or as tin chloride or tin oxide. Apparently only about 700 tons of pig tin were recovered from scrap-tin (not tin-plate) clippings, old tin pipe, tin foil, and collapsible tubes, and it is impossible to give the separate quantities of tin recovered from these sources. Old block-tin pipe is most acceptable scrap, but the quantity available is steadily declining.

Only two plants reported using solely old tin containers, from which the tin coating and solder were first sweated and the black plate was then remelted to make sash weights. One of the makers of sash weights from old cans has stopped using such material on account of the increased cost of labor and fuel. Tin scrap and old tin cans are used in the western mining regions for their iron content for the precipitation of copper from mine waters.

Tin-plate scrap and old cans can not be profitably shipped from western points to reclaiming plants located in Illinois or New Jersey, and the high cost of fuel and labor prevent them being treated locally.

---

[1] A short history of the detinning industry: Met. and Chem. Eng., August, 1917, pp. 187–189.

The scarcity of scrap iron now, however, should result in a larger demand for old cans by mine operators.

An increased quantity of tin was recovered in bronze, and a considerable part of the brass remelted contains a small quantity of tin and of lead. Other alloys from which secondary tin was recovered were solder, babbitt, pewter, terne metal, and electrotype metal.

From reports received by the Geological Survey there were approximately 173,000 long tons of clean tin-plate scrap detinned in 1917. This scrap yielded 10,608,042 pounds of tin oxide, tin bichloride, and tin tetrachloride containing 4,485,745 pounds of tin, also 2,180,144 pounds of tin as metal. There were about 15,000 long tons of old tin-coated containers used, from which tin chloride containing 453,700 pounds of tin was recovered. The average metallic content of the tin oxide was given as 78.6 per cent, that of the tin bichloride as 23 per cent, and that of the tin tetrachloride as 45.4 to 46 per cent.

The average recovery of tin from old tin-coated containers was 27 to 32 pounds a long ton. The insignificant quantity of tin recovered from scrap tin plate and terneplate is shown by the fact that it is estimated that 27,600 long tons of tin were used in 1917 to coat sheets and other forms and that the total recovery of tin from tin-plate scrap and from old containers was about 3,147 tons, of which only about 400 tons was obtained from old containers.

A small quantity of old cans was used by makers of window sash weights, but nearly all the old cans utilized in 1917 were treated by the dry chlorine process at plants in New Jersey owned by the Metal & Thermit Co. and the Vulcan Detinning Co. Most of the cans were received from Washington, Philadelphia, New York, Newark, Pittsburgh, Buffalo, and Rochester, mainly from contractors gathering garbage and waste which was handled by means of picking belts. The cans purchased were classified as follows:

Class 1. Unused empty and unrusted tin cans not exceeding the 1-gallon size, with or without labels attached, but otherwise free from foreign material such as ice, water, ashes, paint, varnish, white lead, and similar insoluble (in water) contents.

Class 2. Used cans not exceeding the 1-gallon size and otherwise as described in class 1.

Class 3. Used empty and unrusted tin cans exceeding in size the 1-gallon size but not exceeding the 5-gallon size and otherwise as described in class 1.

Each class should be packed separately and shipped in quantities weighing not less than 5,000 pounds net, In order to facilitate handling and save space it is advisable to crush or bale the cans. Care must be taken that the cans are not flattened entirely. A spacing of one-half to three-quarters of an inch should be left between the sides of the cans so that they can be cleaned and treated. During the first half of 1918 the quoted prices for old tin cans were $11 to $12 a long ton (2,240 pounds) delivered at Sewaren, N. J., or Chrome, N. J.

The high prices now prevailing and the acute scarcity in the United States of pig tin and scrap steel have resulted in many inquiries as to whether old tin-coated containers could be profitably treated. Several municipalities were considering the installation of plants designed to treat all the waste material collected, including old tin cans. Considered from a local point of view such a plant is very desirable, and the recovery of tin is most essential and of national importance. It is hoped that investigation now being conducted will determine whether a detinning plant can be profitably operated by a municipality. If the combustible part of the city refuse were used for power to operate a garbage plant the tin recovered by heat treatment of the cans would be small in quantity and of inferior quality and the burnt sheet steel would be most undesirable scrap and difficult to dispose of on account of the tin and solder attached to it. The cans if bright and clean could be cut and flattened and possibly could be sold for making toys and other small light articles.

The tin from old cans is best treated by dry chlorine gas, which practically removes all the tin and solder and leaves the sheet steel clean and desirable material for remelting except for its light weight and surface area. A plant using the chlorine process, which is patented, would be expensive and would require a large supply of cans to insure continuous operation. In addition to high costs of labor and material and the difficulty in obtaining machinery and equipment there might be difficulty in obtaining an ample and steady supply of chlorine.

The companies now operating detinning plants have stated their willingness to increase the capacity of their plants. This has not been necessary, for they have not been receiving as large shipments of old cans as they are capable of treating. Several of the shippers in 1917 have found that with increased cost of labor, cartage, and freight it is unprofitable to ship cans from Washington and other cities. At present the detinning plants can handle 800 long tons a month more than the quantity received.

The best method of increasing the recoveries of tin from old cans would be by a more systematic collection of cans that have been properly segregated by the householder. If clean, rustless old cans were collected and dumped directly into cars they could be profitably shipped. With a gross price of $12 and a net price of $6 or less a ton it is obvious that 7,000 or 8,000 cans can not be handled more than once when they are sold for about one-tenth of a cent a can.

It was stated in the report on secondary metals for 1916 that it was improbable that there would be any appreciable quantity of tin recovered from old cans treated in Great Britain. Apparently there is no necessity of modifying the statement, as the Daily Metal Reporter of August 17, 1918, quotes a report made by Borough Engineer P. H. Palmer to the Hastings Corporation (English) that he had for many years saved old tins collected with refuse from households; that up to the time of the war it had always been possible to dispose of old tins, but thereafter there had not been any sales. On the other hand, it has been announced by the British National Salvage Council that there was at least one firm which would purchase old cans provided they were clean, free from rust, and were supplied in quantities.

The British Director General of National Salvage, David Currie, has delivered a very interesting lecture[1] on the reclamation of tin from old containers and tin-plate scrap. He stated that one of the reasons why old cans seem so important to the public eye is that they are very bulky and often gaudy objects compared with the actual amount of material fabricated and that the lack of enterprise in treating old cans was caused by the difficulty of collection and transportation. The following outline of the various methods of recovering tin from tin-plate scrap and old cans was given:

---

[1] The American Metal Market, June 13, 1918.

> The broad principles underlying the patents taken out from 1871 to 1918 for recovering the tin and steel were as under:
>
> (*a*) The recovery of tin as chloride by dissolving the tin from the steel in acids.
>
> (*b*) By dissolving the tin from the steel in caustic soda or potash as a stannate solution.
>
> (*c*) By the action of chlorine on the scrap to combine with the tin to form anhydrous tin tetrachloride.
>
> (*d*) Recovery by dissolving tin in an aqueous solution of tin tetrachloride to form stannous chloride, which in turn is electrolyzed, the tin recovered setting free chlorine, which recombines to produce tin tetrachloride for further use.
>
> (*e*) The recovery of tin from tin tetrachloride electrolytically.
>
> (*f*) Recovery of tin from stannate solutions electrolytically.

There will probably be no appreciable increase in the quantity of tin recovered by detinning old cans in 1918. Owing to the active canvass inaugurated by the Red Cross and other organizations the quantity of tin recovered from tin foil and collapsible tubes should be greater in 1918 than in 1917. If everyone could be induced to save foil and tubes the total quantity of tin saved from such sources would aggregate several thousand tons. However, it is more probable that the quantity will not exceed 1,000 to 1,500 tons, though between 7,000 and 8,000 tons of tin were used in the manufacture of foil and tubes in 1917. Thousands of solid silver and gold or silver plated articles have also been collected, and most of the base metal in the plated ware contained considerable tin.

Owing to the scarcity of pig tin and the difficulty of obtaining small quantities for uses other than those classed as strictly essential, there has been a very active demand for tin scrap and for alloys containing tin, especially tin pipe and No. 1 pewter. The available supply of block-tin pipe, which never was plentiful, has practically been exhausted. Scrap No. 1 pewter is a good substitute for use by brass foundries in place of pig tin, as it should contain not less than 84 per cent tin. The conservation campaign of the Red Cross should not only cover tin foil and collapsible tubes but should include old table ware and plated articles of every kind, for in the aggregate the quantity of tin recovered would be nearly as large from pewter as from foil and tubes. A large part of the silver-plated articles collected would consist of No. 2 pewter, which is not suitable for brass-foundry alloys or for solder but which could be used in place of pig tin in making electrotype metal.

ECONOMIES IN USE OF TIN.

It has been realized that, although the quantity of tin recovered from scrap metals and drosses could be increased, such increased recovery would be proportionately small as compared with the increased consumption. It has therefore been necessary to restrict the use of tin in order that there would be an ample supply for war material and for tin plate used to make food containers. Many of the former uses have been modified or eliminated altogether, and attention has been drawn to wastes caused by ignorance, carelessness, or indifference. Other materials have been substituted for tin foil and collapsible tubes, and the tin content of the foil and tubes made has been reduced. The consumption of tin plate has materially increased (estimated production for 1918 is 35,000,000 base boxes), but the increase has been due solely to the larger quantity used for food containers. The use of tin plate for roofing, for stove boards, and for fire doors has been almost eliminated. It is stated also that a large saving in tin plate has been effected by agreement with manufacturers of tobacco to use plain black or annealed or galvanized sheets instead of tin plate.

STATEMENT OF THE WAR INDUSTRIES BOARD.

The War Industries Board, at Washington, D. C., has assiduously striven to find substitutes for tin and to effect economies in the composition and use of solder, babbitt, bronze, and other bearing metals, and the tin section of the board has issued the following statement:

EXPERIMENTS TO FIND ECONOMIES.

On account of the limited supply of tin available in the world to-day and because of the hazard involved in connection with our overseas imports upon which we depend for our requirements, and, furthermore, because our war program calls for a very large tonnage of tin, it is imperative that we take immediate steps to husband our resources: First, by eliminating all waste; second, by substituting other metals wherever practicable; third, by reducing the percentage of tin used in various alloys just as far as possible; and finally, by recovering larger quantities.

The War Industries Board has conferred recently with representative manufacturers of babbitt and other bearing metals, solder, and miscellaneous tin-alloy products for the purpose of explaining the present situation, and in order to obtain suggestions as to the most practicable methods for conserving tin. In cooperation with the Bureau of Standards, a number of experiments have been conducted. * * *

The accompanying statement reports some of the findings of the Bureau of Standards resulting from their experiments and from inquiries made among a number of large manufacturers and consumers. We realize that these suggestions cover only a few means of reducing our consumption of tin. The War Industries Board will gladly welcome others, particularly as it is expected that each recipient will be influenced in his approach to the problem by consideration of the special needs of his own line of products and manufacturing equipment. It is hoped that the very wisest possible use will be permitted of any original finding that may result from a careful study of the problem.

The suggestions for conservation of tin above referred to are as follows:

BABBITT AND OTHER BEARING METALS.

Many specifications for bearing metals now in existence call for virgin tin (Banca or Straits). A large saving of these high grades of tin could be brought about by allowing the use of second-quality pig tin in making tin-base babbitt. Detrimental impurities could still be limited, but lead could be allowed to a maximum of 1 per cent. This would not be harmful in any way to a tin-base or lead-base lining metal.

There is no question but that the tin content can be reduced somewhat in all bearing alloys. In a few cases, such as for airplanes, crankshaft bearings, etc., it may not be feasible to reduce the tin content by any but a small percentage, whereas in other cases it can be cut down very considerably. In the present emergency every possible saving, however small, should be effected.

For those cases where genuine babbitt is now used and which require a very high grade of lining, alloys such as the following are suggested:

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Tin	85	84	65	62
Antimony	10	8		
Copper	5	8	3 to 6	4
Zinc			28 to 30	33
Aluminum				1

One large bearing-metal manufacturing concern states that the tin should be reduced in favor of lead. Lead-base linings can be used in many cases where tin-base linings are now used, and in general are just as satisfactory. Many manufacturers already use the lead-base metals, but their use could be made more universal. Several special types of lead-base linings, hardened with alkali or alkali earth, are reported to be giving very satisfactory service in place of high-tin babbitt.

One firm states that it is using the following composition instead of Nos. 2 and 3 above in order to conserve tin:

Substitute 2:	Per cent.
Tin	8
Antimony	8
Copper	4
Lead	80

Substitute 3:	Per cent.
Tin	5
Antimony	7
Copper	2
Lead	10
Zinc	76

These have apparently been found to do the service required of the tin-base linings in machine-tool work.

Another large manufacturer of machine tools does not use lined bearings at all, believing that bronze alone is sufficient. There is probably no question, however, but what the lined bearing is cheaper because of the less amount of machining necessary in making the bearing. It is also claimed that the cost of replacement of a lined bearing is less than that of a bronze bearing and has to be made less frequently. One way in which a lining metal can be saved is to use just as thin a lining as it is possible to have in order to maintain a high enough temperature during pouring to insure a firm bond and solid mass of metal.

In place of a bronze used for bearings containing 80 per cent copper, 10 per cent tin, and 10 per cent lead, the following might be substituted as having been thoroughly tried and found satisfactory:

	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Copper	81	79	74	74	(a)	(a)
Tin	7	5	5	5	8	5
Lead	9	15	20	25	15	17½
Zinc	3				1½ to 3	5
Antimony				5		
Phosphor copper	1	1	1	1		

[a] Remainder.

With the cooperation of all in consideration of the above suggestions, it seems probable that much less tin could be used in bearing metals without in any way impairing their service. It is believed that a saving of at least 25 per cent could be brought about by a judicial selection of the proper composition of either bronze or lining to use for each particular service and insisting upon its use.

SOLDER.

There is apparently very little excuse for using a 50—50 solder or high-tin solder for any purpose whatever except in the matter of appearance of the finished article, and in the present emergency this is of secondary importance.

For hand soldering with an iron 45—55 will answer for all purposes, but for most purposes 40—60 will be satisfactory. Wiping solder used by plumbers should not contain over 37½ per cent tin, whereas many are now using 40—60.

Can manufacturers and canners by adopting proper machinery can use 37½—62½ solder with satisfactory results. Very little solder of a higher tin content need be used in these industries.

Manufacturers of radiators need not use solder above 40—60 and in a majority of cases 35—65 will be found entirely satisfactory, and often lower tin content can be used, providing the solder is kept free from antimony. The use of pure tin in radiator construction appears extravagant. If this is used merely for tinning purposes, preparatory to soldering, the eutectic of tin and lead—63 per cent tin and 37 per cent lead—will be found to serve the purpose just as well. This should, in fact, be used generally where it is necessary to tin an article before soldering.

(In all of the foregoing paragraphs on solder the figure first mentioned refers to tin. For example, 40—60 means 40 per cent tin, 60 per cent lead.)

The possibility of using cadmium as a substitute for tin in solder appears promising. Laboratory and manufacturing tests, made by the bureau and by some of the large users of solders, have given good results. Among others the composition containing 80 per cent lead, 10 per cent cadmium, and 10 per cent tin has shown particular promise. The board will be glad to report more fully on this phase of the subject as soon as further commercial tests of cadmium solders have been made. No difficulty is anticipated in connection with the production of cadmium on a commercial basis at a price considerably less than tin as soon as it has been demonstrated that its use for this purpose can be generally extended.

RECOVERY FROM SKIMMINGS.

Probably most large consumers of both solder and babbitt metals save their skimmings and residue. In the present emergency, small consumers as well as large should make a special endeavor to see that all metal in this form is recovered. It is believed that the aggregate that is lost through these skimmings not being saved is considerable and that with a full appreciation of the importance of saving such metal the gain will be appreciable.

TIN ALLOY CASTINGS.

It is believed that the percentage of tin in most alloy castings is unnecessarily high. It has furthermore been found that aluminum, bronze, steel, brass, or other materials can often be substituted in the manufacture of tin-alloy castings. Wherever possible the percentage of tin in the alloy should be reduced or another metal substituted.

It has been stated that it is a common but questionable practice in brass foundries to look upon tin as the cure for most troubles encountered in the production of brass and bronze castings. In view of the present situation brass and bronze foundries are requested to curtail the consumption of tin whereever possible and to restrict its use to the proved essential needs.

The leading manufacturers of white metals have organized the War Service Association of the Manufacturers of Solder and Babbitt Metal, and the plans of the association include active cooperation with the Government in fixing standard formulas with tin content as low as feasible during the period of the war.

SECONDARY ALUMINUM.

The recovery of secondary aluminum as pig aluminum or in alloys in 1917 amounted to 16,100 tons, valued at $16,711,800, as compared with 19,300 tons, valued at $23,430,200, in 1916. The quantity recovered in alloys amounted to 9,440 tons.

Various products are made by smelters and refiners from scrap aluminum. One sample of pig aluminum, which was made from clean sheet-aluminum clippings, shows the following analysis:

Analysis of secondary aluminum.

Aluminum	98.75
Copper	.16
Silica	.11
Iron	.56
Manganese	.42
	100.00

The standard No. 12 alloy is the best known and most widely used of aluminum casting alloys. It contains a minimum of 92 per cent aluminum and from 7 to 8 per cent copper. Another alloy made by a large secondary aluminum smelter contains 4 per cent zinc, 8 per cent copper, and the remainder aluminum. Some of the reasons for defective aluminum castings are given by L. M. Brile.[1]

Aluminum chips from castings used in the manufacture of automobiles have become a large source of secondary aluminum. By the old methods of treatment the loss in remelting such chips was sometimes as much as 40 per cent. A publication issued by the United States Bureau of Mines[2] gives an account of experiments which resulted in reducing such losses to as little as 10 per cent.

On account of the difficulty in obtaining virgin pig aluminum for nonmilitary uses a considerable quantity of scrap aluminum is now purchased directly by foundries instead of being purchased and refined by secondary smelters. For this reason it is deemed advisable to reproduce the following article, written by Charles Vickers and published in the Daily Iron Trade and Metal Market Report of August 12, 1918:

Scrap aluminum.—New sheet aluminum clippings must consist of new sheet aluminum and cuttings, must be free from oil, grease, and any other foreign substances, and must be guaranteed not less than 98 per cent pure aluminum.

When sheet aluminum is compressed into briquettes little difficulty is experienced in using it for making aluminum castings, but it is difficult material to melt when loose, as the crucible contains only a small amount at each charge. A great deal of attention, therefore, is required, and considerable metal always is spilled into the furnace. Hence sheet clippings should always be shaped into massive forms. It is fairly good material for making castings when it has a purity of 98 per cent, but it is similar to aluminum wire in that respect, as the specifications for this material require a purity from 98 to 99 per cent also. Aluminum wire is not difficult to charge for melting provided that when cut into suitable lengths it is not permitted to untwist if be in the form of cable. Wire of single strand has to be coiled or compressed into bundles; otherwise it is a most tedious operation to melt it into ingots or castings.

The cost of melting aluminum clippings or wire will depend upon their physical condition. In the case of loose wire in short lengths, produced by the untwisting of cut aluminum cable, the melting cost in a careful test of 500 pounds of wire amounted to $2.62 per 100 pounds, and this was when labor was much cheaper than now. Included in this cost were labor, crucibles, fuel, and loss, but the labor cost was more than all the other costs combined. The loss was 7 per cent. It will be realized that if finely divided aluminum is to be melted economically, some method of forming it into packages of massive size is essential.

The metal, either wire or clippings, forms a good basic metal for ordinary castings and can be alloyed the same as the ingot metal. But owing to the presence of a considerable amount of impurities, trouble from excessive shrinkage of the alloys is likely to arise more often than would be the case if pure aluminum were used. Unless the material be in good shape for charging into the pots, its cost when melted would be near that of pure aluminum ingot, and this must be taken into consideration when deciding upon the particular kind of raw material to use for the work in view.

---

[1] Metal Industry, February, 1916, pp. 86–87.

[2] Gillett, H. W., and James, G. M., Melting aluminum chips: Bur. Mines Bull. 108, 1916.

The temperature of the aluminum should be kept at about a red heat, and after the crucible is as full as desired, a flux of zinc chloride should be used to disentangle the oxide from the metal.

The scrap metal specifications insist that aluminum castings shall be free from iron, babbitt, brass, and any other foreign substance and must not exceed 2 per cent of oil and and grease.

Aluminum alloys may be divided into two groups, those that contain zinc and those that do not. The first group may contain any amount of zinc from 1 or 2 per cent up to 30 per cent, with or without copper. The second group consists of alloys of copper and aluminum, with rarely more than 8 per cent copper, this latter alloy being known as No. 12 aluminum. Since both these groups are used indiscriminately for making aluminum castings, it is obvious that an assortment of scrap will contain alloys both with and without zinc content. The result is that when melted it is impossible to keep the composition at all regular. Consequently, this chance must be taken when using this type of scrap metal.

Aluminum zinc alloys are not considered suitable for certain classes of aluminum castings, although in general they are stronger than the alloys of aluminum with copper. The aluminum zinc alloys shrink and check more than the aluminum copper alloys; and the higher the content of zinc in the alloy, the more the tendency to shrink, until with over 30 per cent of zinc a peculiar shrinkage trouble is likely to manifest itself on the lower parts of castings of heavy section. The result is that zinc is considered most undesirable in scrap aluminum, and if some easy and inexpensive method could be devised whereby the zinc could be eliminated from aluminum scrap it would be a boon to the scrap metal trade. The best that can be done at present is to alloy the aluminum with zinc-free metals to bring the zinc content down to a point where, while undesirable, it is not harmful for most purposes.

For special purposes, scrap aluminum castings are undesirable, but examples of castings where this material can be used to good advantage are numerous, as it is considerably cheaper than new aluminum or scrap rolled material. In the case of unimportant castings of such section as are easy to cast, scrap aluminum is a desirable and economical material to use, and it can be run directly into castings after it is melted down. In some cases, additional zinc can be added further to cheapen the alloy. This is not difficult provided the scrap comprises castings of similar sort, like gear casings, instead of being a heterogeneous mixture. In such a case the scrap will be of similar composition; and if a trial heat be made with zinc addition, there will be little difficulty in deciding the amount of zinc to be added to cheapen the mixture.

Scrap aluminum castings are easy to melt and recast, as the metal is broken with ease and easily charged into the crucibles. The only thing to be careful of is to keep the temperature below a cherry red between the intervals of charging new metal. When the crucible is as full as desired, a small piece of zinc chloride should be added and stirred into the metal to clear the surface. When the alloy contains much zinc, a little sal ammoniac has been found to do good, as this is the best flux to use in the case of zinc. For zinc aluminum, chloride of zinc is the best flux.

SECONDARY NICKEL.

An effort was made for the first time in 1916 to ascertain the quantity of secondary nickel as nickel or in alloys. The reports received in 1917 showed that 860 tons of nickel were recovered in that year, a considerable part of which was from clean new scrap. This does not include any nickel in scrap ferrous alloys nor the recoveries from secondary sources made by the International Nickel Co. The scrap remelted by the International Nickel Co. is included with matte and ore, and no separate recovery is attempted. The quantity of nickel in matte and in ore imported into the United States in 1917 was 75,510,793 pounds, most of which was from the Sudbury district, in Ontario. No direct production of nickel from American nickel ores is known to have been made in the United States in recent years, but an equivalent of about 402 short tons of nickel was saved in 1917 as a by-product in the electrolytic refining of copper.

The Missouri Cobalt Co., of Fredericktown, Mo., mined ore in 1917 which contained copper, nickel, and cobalt. A new refinery has been built at which the residues returned from the ore shipped to sulphuric acid plants will be treated for the nickel, cobalt, and copper content.

As the greatest use for nickel is as an alloy in steel, and the secondary recoveries of nickel reported to the Survey in 1917 were solely from nonferrous scrap, it is evident that the 860 tons of nickel reported form a small portion only of the nickel in alloys recovered and reüsed. The secondary nickel reported in 1917 was nearly all recovered from old nickel anodes, German silver, and Monel metal. Analyses of various nickel alloys have been published by the United States Geological Survey.[1]

---

[1] Hess, F. L., Nickel: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, pp. 763–765, 1917.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN MONTANA.[1]

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

GENERAL STATEMENT.

Mines in Montana produced during the calendar year 1917 gold, silver, copper, lead, and recoverable zinc valued at $110,149,382. There were 617 producers. In 1916 there were 513 producers, and the output was valued at $133,882,947. The decrease of $23,733,565, or more than 17 per cent, in value in 1917 was due to the decreased output of copper, silver, gold, and zinc. Silver Bow County, which includes the Butte or Summit Valley district, produced more than 19 per cent of the gold, nearly 88 per cent of the silver, 98.5 per cent of the copper, more than 47 per cent of the lead, nearly 97 per cent of the zinc, and more than 93 per cent of the total value of the output from deep mines.

Mine production of gold, silver, copper, lead, and zinc in Montana in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	513	7,860,425	$4,550,494	16,494,366	352,928,373	13,595,136	229,259,075	$133,882,947
1917	617	6,307,164	3,517,253	13,128,142	274,462,574	21,951,220	186,259,331	110,149,382
Increase or decrease, 1917	+104	−1,553,261	−1,033,241	−3,366,224	−78,465,799	+8,356,084	−42,999,744	−23,733,565

[a] Includes placer production.

ORE.

The total quantity of ore sold or treated was 6,307,164 tons, and the total average value per ton increased from $16.94 in 1916 to $17.39 in 1917. The average value per ton of the gold and silver contained in this ore increased from $1.87 to $2.20. Mines in Silver Bow County are credited with the largest output of ore (5,681,058 tons), of which 4,775,213 tons, or more than 84 per cent, was copper ore; 633,901 tons, lead-zinc ore; 13,483 tons, dry or siliceous ore; and 258,461 tons, zinc ore.

---

[1] The statistical tables in this report were compiled by Bessie N. Patchell, of the United States Geological Survey.

The total output of dry or siliceous ore in the State was 444,222 tons, of which 411,118 tons were classified as gold ore, 7 tons as gold and silver ore, and 33,097 tons as silver ore. The largest part, or 318,823 tons, of dry or siliceous ore, together with 9,862 tons of old tailings, was treated by cyanidation, and 8,925 tons were treated by amalgamation. There were 503,023 tons shipped directly to the smelters for treatment, and 5,086,706 tons were treated at concentration mills. Phillips, Lewis and Clark, and Fergus counties, with 223,350 tons, 69,848 tons, and 38,133 tons of ore, respectively, were the largest producers of strictly siliceous ores. To Deer Lodge County there was credited 52,133 tons of dry or siliceous ore, of which 52,005 tons were oxidized iron ore. This ore, which contained more than 20 per cent excess iron and a little gold and was valuable as a flux at the smelter, was mined in the Georgetown district of Deer Lodge County, and a similar ore, of lower grade, containing gold, silver, and a little copper, was mined near Elkhorn, in Jefferson County. Iron sulphide ore aggregating 3,471 tons, containing nearly an ounce of gold per ton and a little silver and copper, continued to be mined in Broadwater County, near Radersburg.

The output of copper ore was 4,844,537 tons, of which 4,136,130 tons were of milling grade and produced 1,492,104 tons of concentrate averaging 32 cents in gold and 4.87 ounces of silver per ton and 7.14 per cent of copper and having an average value per ton of $43.33. From 3,344 tons of copper-lead ore there were 1,545 tons milled and 515 tons of copper-lead concentrate produced, which averaged $6.12 in gold and 24.88 ounces of silver per ton, 3.92 per cent of copper, and 15.18 per cent of lead and had an average value per ton of $74.15. One property in the Boulder district, Jefferson County, yielded 1,012 tons of milling ore, from which 234 tons of copper-lead-zinc concentrate were produced. The copper ore of shipping grade amounted to 380,130 tons, largely sulphides, containing 24 cents in gold and 3.73 ounces of silver per ton and 5.68 per cent of copper and having an average value of $34.36 a ton.

Most of the lead ore produced, or 20,402 tons, was shipped directly to the smelters and contained $4.18 in gold and 17.65 ounces of silver per ton, 0.06 per cent of copper, and 11.33 per cent of lead and had an average value per ton of $38.54. Lead concentrates were separated from lead-zinc ore, of which 67,783 tons were treated, and produced 7,409 tons of lead concentrate, averaging $3.26 in gold and 22 ounces of silver per ton, 0.17 per cent of copper, and 39.56 per cent of lead. The average value per ton of all lead concentrates was $84.33.

Zinc concentrates recovered from zinc ore, lead-zinc ore, and copper-lead-zinc ore aggregated 285,621 tons, averaging 45 cents in gold and 8.82 ounces of silver per ton, 0.40 per cent of copper, 1.40 per cent of lead, and 32.03 per cent of zinc, the total average value per ton being $77.65. Lead-zinc concentrates recovered from lead-zinc ore aggregated 6,178 tons, containing a trace of gold, 10.22 ounces of silver per ton, 8.40 per cent of lead, and 22.80 per cent of zinc, the average value per ton being $71.12.

Ore and metals produced in Montana in 1917.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	99	....	22,594.17	3,551	....	....	....
Dry or siliceous ore	215	444,222	107,172.83	954,477	543,456	268,464	....
Copper ore	120	4,844,537	27,561.56	8,911,389	271,331,853	820	....
Lead ore	178	28,923	4,688.65	388,435	55,780	5,554,911	....
Zinc ore	11	258,846	1,475.24	378,239	768,690	3,539,184	34,032,936
Copper-lead ore	8	3,344	223.45	95,747	156,675	1,073,182	....
Lead-zinc ore	16	726,280	6,373.21	2,386,824	1,580,520	11,456,659	152,101,530
Copper-lead-zinc ore	1	1,012	58.00	9,480	25,600	58,000	124,865
	......	6,307,164	170,147.11	13,128,142	274,462,574	21,951,220	186,259,331

Ore sold or treated in Montana in 1917, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore. ore.	Lead-zinc ore.	Copper-lead-zinc ore.	Total.
Beaverhead	5,820	1,025	3,201	....	1,647	37	....	11,730
Broadwater	3,547	6,376	1,199	22	....	....	....	11,144
Cascade	3,665	....	3,126	....	....	....	....	6,791
Deer Lodge	52,133	47	....	....	....	....	....	52,180
Fergus	38,133	....	11	....	....	....	....	38,144
Gallatin	....	18	....	....	....	....	....	18
Granite	16,730	4,128	263	....	....	....	....	21,121
Jefferson	5,792	30,521	10,969	363	1,001	17,974	1,012	67,632
Lewis and Clark	69,848	148	7,405	....	....	258	....	77,659
Lincoln	630	....	....	....	....	61,647	....	62,277
Madison	10,167	3,291	1,062	....	....	....	....	14,520
Meagher	....	830	43	....	....	....	....	873
Mineral	33	22,076	93	....	....	363	....	22,565
Missoula	400	214	74	....	....	....	....	688
Park	80	32	53	....	....	....	....	165
Phillips	223,350	....	....	....	....	....	....	223,350
Powell	411	417	1,308	....	9	....	....	2,145
Ravalli	....	....	....	....	....	12,100	....	12,100
Sanders	....	201	116	....	687	....	....	1,004
Silver Bow	13,483	4,775,213	....	258,461	....	633,901	....	5,681,058
	[a]444,222	4,844,537	28,923	258,846	3,344	726,280	1,012	6,307,164
Value per ton in gold and silver	$6.76	$1.63	$14.42	$1.32	$24.97	$2.89	$8.90	$2.20

[a] Includes 411,118 tons of gold ore, 7 tons of gold and silver ore, and 33,097 tons of silver ore.

GOLD.

The mine production of gold in Montana decreased from $4,550,494 in 1916 to $3,517,253 in 1917. Lewis and Clark County is credited with the largest total output, $872,529 from deep and placer mines; Silver Bow County followed with $690,801, and Madison County with $500,703. The output of the placers amounted to $467,063, against $723,159 in 1916, a decrease of nearly 36 per cent. The largest output of gold from deep mines came from Lewis and Clark and Silver Bow counties, followed by Deer Lodge, Phillips, and Fergus counties. At amalgamation and cyanidation plants $1,383,097 in gold was produced, or an average recovery of $4.10 per ton of ore and tailings treated. Gold in bullion from deep mines came principally from Lewis and Clark, Phillips, and Fergus counties, with a distinct increase in Lewis and Clark County, as the Piegan-Gloster & Shannon property in that county was the largest producer from that source in Montana. The output from these counties alone was valued at $1,319,201. In 1916 these three counties produced gold valued at $1,353,263 at gold and silver mills, and Phillips County, or the Little Rockies district, was the most productive locality. Ore treated at concentration mills produced concentrates containing $675,460 in gold, or 38 cents per ton. The crude ore shipped to smelters contained $984,625 in gold, or an average per ton of $1.96. The placer gold produced was chiefly the output of one company operating 3 dredges in Alder Gulch, Madison County.

More than two-thirds of the total gold in 1917 was produced from 6 properties, which, named in order of output, were the Anaconda mines, chiefly from copper ores; the Shannon-Piegan-Gloster mines, near Marysville, from siliceous ores; the Southern Cross mine, from oxidized iron ores at Georgetown; the Conrey placers in Alder Gulch, Madison County; the Ruby Gulch mines in Phillips County; and the North Moccasin mine in Fergus County. Each of the two last-mentioned yielded gold from low-grade siliceous gold ore.

Mine production of gold in Montana in 1917, in fine ounces.

County.	Placers.	Deep mines.							Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-lead-zinc ore.	
Beaverhead	27.82	1,421.30	115.09	134.75		62.95			1,761.91
Broadwater	238.54	2,183.32	37.77	413.31					2,872.94
Cascade		133.86		86.49					220.35
Deer Lodge		22,087.29	.15						22,087.44
Fergus		12,985.35		19.54					13,004.89
Granite	634.82	5,528.21	63.80	6.05					6,232.88
Jefferson	35.94	1,137.89	296.94	1,812.23	25.00	153.67	1,772.85	58.00	5,292.52
Lewis and Clark	300.55	41,074.00	.93	828.43			4.68		42,208.59
Lincoln	1.11	562.17					445.00		1,008.28
Madison	20,006.45	2,979.96	28.59	1,206.51					24,221.51
Meagher	29.95		.38						30.33
Mineral	340.13	12.99	96.62						449.74
Missoula	60.08	300.02	9.19						369.29
Park	12.43	104.00	.25	7.69					124.37
Phillips		15,703.88							15,703.88
Powell	686.63	89.39	38.05	173.65		1.84			989.56
Ravalli	40.20						96.27		136.47
Sanders	2.56		7.11			4.99			14.66
Silver Bow	176.96	869.20	26,866.69		1,450.24		4,054.41		33,417.50
	22,594.17	[a]107,172.83	27,561.56	4,688.65	1,475.24	223.45	6,373.21	58.00	170,147.11

[a] Includes 103,835.47 ounces from gold ore, 2.20 ounces from gold and silver ore, and 3,335.16 ounces from silver ore.

SILVER.

Mines in Montana produced 13,128,142 ounces of silver, valued at $10,817,589, in 1917. The quantity produced was more than 20 per cent less than in 1916. From copper ore 8,911,389 ounces of silver were obtained, an average of 1.84 ounces per ton. However, nearly all of the copper ore produced was milled and the concentrates averaged 4.87 ounces of silver per ton. The silver output of Silver Bow County decreased 3,472,171 ounces, but increases in other counties reduced the State decrease. Jefferson County had the largest increase in silver. Cyanidation and amalgamation mills yielded precipitates and bullion containing 235,068 ounces, concentration mills produced concentrates containing 10,053,994 ounces, and crude ore shipped to smelters contained 2,580,608 ounces.

More than 81 per cent of the total silver was produced from six properties, the Anaconda mines leading, followed by the Butte & Superior, North Butte, Elm Orlu, and East Butte mines, all in Silver Bow County, and the Granite-Bimetallic property, in Granite County.

Mine production of silver in Montana in 1917, in fine ounces.

County.	Placers.	Deep mines.							Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-zinc ore.	Lead-zinc ore.	Copper-lead-zinc ore.	
Beaverhead	2	35,436	4,898	21,029	....	77,938	....	....	139,303
Broadwater	41	2,362	1,269	13,527	153	....	....	....	17,352
Cascade	....	67,750	....	136,428	....	....	....	....	204,178
Deer Lodge	....	20,228	589	....	....	....	....	....	20,817
Fergus	....	2,786	....	193	....	....	....	....	2,979
Gallatin	....	....	3	....	....	....	....	....	3
Granite	176	394,586	35,387	15,657	....	....	....	....	445,806
Jefferson	12	11,269	67,625	126,197	3,558	13,178	93,367	9,480	324,686
Lewis and Clark	56	103,561	329	51,659	....	....	502	....	156,107
Lincoln	....	157	....	....	....	....	89,980	....	90,137
Madison	3,136	22,893	1,409	10,529	....	....	....	....	37,967
Meagher	4	....	103	531	....	....	....	....	638
Mineral	10	....	1,761	2,196	....	....	3,158	....	7,125
Missoula	3	47	298	295	....	....	....	....	643
Park	1	25	18	960	....	....	....	....	1,004
Phillips	....	131,341	....	....	....	....	....	....	131,341
Powell	84	503	2,789	5,181	....	162	....	....	8,719
Ravalli	4	....	....	....	....	....	16,155	....	16,159
Sanders	....	....	3,056	4,053	....	4,469	....	....	11,578
Silver Bow	22	161,533	8,791,855	....	374,528	....	2,183,662	....	11,511,600
	3,551	[a]954,477	8,911,389	388,435	378,239	95,747	2,386,824	9,480	13,128,142

[a] Includes 281,334 ounces from gold ore, 47 ounces from gold and silver ore, and 673,096 ounces from silver ore.

COPPER.

Montana produced 274,462,574 pounds of copper in 1917, valued at $74,928,283. This total represents a decrease of 78,465,799 pounds in quantity and $11,892,097 in value in 1917. Silver Bow County, or practically the Butte district, contributed all the copper except 3,869,673 pounds. Mines in Jefferson County produced the next largest quantity, 1,215,385 pounds, followed in order by Broadwater, Mineral, and Granite counties. Crude ore of various kinds shipped to smelters in 1917 contained 43,912,757 pounds of copper, or an average of 4.36 per cent. The sulphide copper ore of smelting grade predominated and contained 41,562,810 pounds, an average of 5.89 per cent, and the oxidized copper ores contained 1,674,684 pounds, or 123 per cent. Copper precipitates produced from mine waters and the washings from old tailings contained 14,151,721 pounds. The Washoe works[1] near Anaconda treated during 1917 in the copper leaching plant 598,370.16 tons of tailings, from which there were produced 5,019.67 tons of cement copper. Ore leached, amounting to 54,009 tons, contained 810,139 pounds of copper. Concentrates shipped to smelters, averaging 6.01 per cent of copper, contained 215,587,957 pounds, the bulk of which was from copper concentrates. The output of copper from Butte or Summit Valley district decreased from 349,532,636 pounds in 1916 to 270,567,544 pounds in 1917. In copper production the Anaconda mines at Butte make the greatest output, followed by the North Butte, East Butte, and Davis-Daly properties.

---

[1] Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

Mine production of copper in Montana in 1917, in pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-lead-zinc ore.	Total.
Beaverhead	3,417	128,644	30,310		104,263			266,634
Broadwater	49,518	880,258	1,583					931,359
Cascade			1,023					1,023
Deer Lodge	177,313	9,367						186,680
Fergus	60		185					245
Gallatin		3,627						3.627
Granite	152,749	266,760	474					419.983
Jefferson	4,739	1,043,287	5,354	4,528	30,061	101,816	25,600	1,215,385
Lewis and Clark	101	20,507	8,197					28,805
Madison	10,647	62,354	4,011					77,012
Meagher		80,871						80,871
Mineral		518,375						518,375
Missoula		35,286						35,286
Park		1,154						1,154
Powell		18,376			483			18,859
Ravalli						4,260		4,260
Sanders		53,604	4,643		21,868			80,115
Silver Bow	144,912	268,209,383		764,162		1,474,444		270.592,901
	[a] 543,456	271,331,853	55,780	768,690	156,675	1,580,520	25,600	274,462,574

[a] Includes 382,289 pounds from gold ore, 40 pounds from gold and silver ore, and 161,127 pounds from silver ore.

LEAD.

The mine production of lead in Montana was 21,951,220 pounds, valued at $1,887,805, in 1917, against 13,595,136 pounds, valued at $938,064, in 1916. Of this output, more than 47 per cent was derived from mines in Silver Bow County, which produced 10,352,453 pounds, against 9,195,082 pounds in 1916. The increase was due largely to the output of zinc ore and lead-zinc ore, which were concentrated from Butte mines. The next largest output of lead, or 3,927,559 pounds, came from the mines in Lincoln County, followed by Jefferson County with 2,455,350 pounds. There were large increases in Lincoln, Jefferson, Mineral, Silver Bow, and Lewis and Clark counties. Crude ore of all kinds shipped to the smelters contained about 27 per cent of the total lead (5,877,283 pounds), 15,550,225 pounds were contained in concentrates, and 523,712 pounds in old tailings and slags shipped. Lead ore shipped to smelters contained 4,623,358 pounds of lead, an average of more than 11 per cent, and the lead concentrates contained 6,279,655 pounds, an average of more than 35 per cent. The zinc concentrate contained 8,017,658 pounds of recoverable lead. Two properties at Butte supplied most of this material.

The Butte & Superior property, at Butte, produced the largest quantity of lead in 1917, followed by the Snow Storm in Lincoln County and the Anaconda mines at Butte.

Mine production of lead in Montana in 1917, in pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-lead-zinc ore.	Total.
Beaverhead	3,411	820	680,388		826,298	4,604		1,515,521
Broadwater			325,186	3,014				328,200
Cascade	203,922		1,091,141					1,295,063
Fergus	2,375		2,220					4,595
Granite			57,087					57,067
Jefferson	7,147		1,629,346	24,950	136,080	599,827	58,000	2,455,350
Lewis and Clark	50,853		1,138,557			10,458		1,199,868
Lincoln						3,927,559		3,927,559
Madison	756		428,243					428,999
Meagher			26,994					26,994
Mineral			19,668			40,360		60,028
Missoula			41,394					41,394
Park			38,229					38,229
Powell			50,776		2,603			53,379
Ravalli						32,618		32,618
Sanders			25,682		108,201			133,883
Silver Bow				3,511,220		6,841,233		10,352,453
	[a] 268,464	820	5,554,911	3,539,184	1,073,182	11,456,659	58,000	21,951,220

[a] Includes 61,131 pounds from gold ore and 207,333 pounds from silver ore.

ZINC.

The mine production of recoverable zinc in Montana was 186,259,331 pounds, valued at $18,998,452, in 1917, against 229,259,075 pounds, valued at $30,720,716, in 1916. The bulk of the zinc output was from Silver Bow County, and smaller quantities came from Jefferson, Lincoln, Ravalli, Mineral, Lewis and Clark, Beaverhead, and Broadwater counties. The largest quantity of zinc was contained in the product of the Butte & Superior mine at Butte and amounted to 131,337,299 pounds in concentrate having an average zinc content of 47.36 per cent. All of the zinc concentrate produced in Butte at the Butte & Superior and Elm Orlu mills were shipped to eastern smelting works, but nearly all the zinc ore from the Emma mine and other properties at Butte was concentrated at the Washoe concentrator and the concentrate was shipped and treated at the electrolytic zinc plant at Great Falls. The zinc plants[1] at Washoe and Great Falls treated during the year 326,479.14 tons of ore and other zinciferous material, of which 257,849.93 tons of zinc ore were produced by mines of the company and 68,629.21 tons were purchased from other companies. The plants at Great Falls produced 50,624,524 pounds of electrolytic zinc in 1917, principally from Montana ore but partly from ore from Idaho and Utah.

First in production of zinc in 1917 was the Butte & Superior mine, followed by the Elm Orlu, Anaconda mines, and Emma property, all at Butte.

---

[1] Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

Mine production of recoverable zinc in Montana in 1917, in pounds.

County.	Zinc ore.	Lead-zinc ore.	Copper-lead-zinc ore.	Total.
Beaverhead		15,918		15,918
Broadwater	15,363			15,363
Jefferson	155,664	3,357,556	124,865	3,638,085
Lewis and Clark		31,145		31,145
Lincoln		1,552,867		1,552,867
Mineral		197,595		197,595
Ravalli		491,943		491,943
Silver Bow	33,861,909	146.454,506		180,316,415
	34,032,936	152,101,530	124,865	186,259,331

MINING INDUSTRY.

A systematic campaign to interfere with and prevent the production of metals essential to winning the war was inaugurated in June, 1917, through the activity of the I. W. W. A series of labor disturbances, strikes, and walkouts occurred, which greatly reduced the output of copper ore from the various mines at Butte. This condition lasted through the summer and well into the fall of 1917, automatically closing the concentrators and smelters at Washoe and Great Falls. The smaller operators at Butte, and particularly the zinc producers, the Butte & Superior and the Elm Orlu, were the first to make anything near a normal production of ore. On December 18 the Metal Mine Workers' Union voted to call the labor strikes off and return to work. Wages for miners before the trouble were $4.75 per day and at present are $5.25. Payment is reported[1] to have been based on the sliding scale with a base of $3.50 per day when copper was under 15 cents per pound and advancing 25 cents for every 2 cents increase in the price of copper. This was agreed on by the companies notwithstanding the fact that the price of copper was fixed by the Government in October.

METALLURGIC INDUSTRY.

Various kinds of milling plants, 53 in number, operated in Montana during a part or the whole of the year 1917, some of them only for short periods. Eleven plants used the amalgamation process; 2 used amalgamation and concentration; 1 used concentration and cyanidation; 14 were cyanidation mills; 19 were concentration mills, of which 11 used oil-flotation equipment after table concentration and 2 used the flotation method alone. Included in this total there were 2 copper-leaching plants, 1 electrolytic zinc-leaching plant, and 3 copper-precipitating plants that extracted copper from mine waters. Several small precipitating plants were operated by lessees, whose output was included with that of the lessor. Of the 337,610 tons of ore and old tailings treated at gold and silver mills, 8,925 tons were treated by amalgamation and yielded 2,845.30 ounces of gold and 1,246 ounces of silver, or an average recovery of $6.59 in gold and 0.14 ounce of silver per ton. The ore treated by cyanidation aggregated 318,823 tons, which, with 9,862 tons of old tailings, yielded

---

[1] Min. and Sci. Press, Jan. 5, 1918, p. 20.

64,062 ounces of gold and 233,822 ounces of silver, or an average recovery per ton for ore and old tailings of $4.03 in gold and 0.71 ounce of silver. The total value of the bullion recovered from ore and tailings by both amalgamation and cyanidation was $1,576,793, as against an output in 1916 valued at $1,407,099. During 1917 there were 167 pounds of mercury and 158,215 pounds of sodium cyanide consumed in gold and silver mills. This represented 0.04 pound of mercury per ounce of gold and silver bullion and 0.018 pound per ton of ore treated. The consumption of cyanide was 0.53 pound per ounce of gold and silver bullion and 0.48 pound per ton of ore and tailings treated.

Gold and silver produced at mills in Montana in 1917.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Beaverhead	5,000			1,132.18	6,826	$29,029
Broadwater	[a] 51	189.77	43			3,958
Cascade	9	8.69				180
Deer Lodge	1			.02	17	15
Fergus	[b] 38,133			12,937.42	2,660	269,632
Granite	163	97.60	68			2,074
Jefferson	3	.03	51			43
Lewis and Clark	[c] 61,141	1,136.42	675	[d] 34,038.60	[d] 84,364	797,204
Lincoln	630	562.17	157			11,749
Madison	[e] 2,843	541.06	203	[f] 158.95	[f] 8,548	21,681
Missoula	400	300.00	47			6,241
Park	12	9.56	2			200
Phillips	219,350			[g] 15,703.88	[g] 131,341	432,853
Powell				[h] 83.21	[h] 64	1,772
Silver Bow	12			7.74	2	162
	327,748	2,845.30	1,246	64,062.00	233,822	1,576,793

[a] Also yielded 1 ton of concentrates.
[b] Also yielded 14 tons of concentrates.
[c] Also yielded 11 tons of concentrates.
[d] Includes bullion from 4,962 tons of old tailing.
[e] Also yielded 65 tons of concentrates.
[f] Includes bullion from 500 tons of old tailing.
[g] Includes bullion from 4,000 tons of old tailing.
[h] Bullion from 400 tons of old tailing.

Mills in Montana equipped for the concentration of low-grade ore treated 5,086,706 tons, or about 80 per cent of the total ore mined. The concentrates produced and smelted amounted to 1,793,899 tons, containing 32,675.39 ounces of gold, 10,053,994 ounces of silver, 215,587,957 pounds of copper, 15,550,225 pounds of lead, and 185,851,604 pounds of recoverable zinc, valued in all at $88,109,646, or an average value per ton of $49.12.

Crude ore directly smelted, 503,023 tons, contained 47,631.24 ounces of gold, 2,580,608 ounces of silver, 43,912,757 pounds of copper, 5,877,283 pounds of lead, and 407,727 pounds of zinc, valued in all at $15,646,263, or an average of $31.10 per ton.

The following tables give the quantity of material shipped from the concentration mills and of crude ore shipped to the smelters, with the metals produced, by counties, in 1917:

Mine production of metals from Montana concentrates in 1917.

By counties.

County.	Ore to concentrating mills.	Concentrates produced.						Total value of concentrates.
		Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Broadwater	4,461	261	7.92	53	152,422	....	....	$41,819
Fergus	....	14	47.93	126	60	2,375	....	1,315
Jefferson	48,479	14,872	2,070.22	162,039	1,025,144	749,275	3,485,301	876,117
Lewis and Clark	4,839	1,375	455.76	16,614	3,191	414,957	31,145	62,845
Lincoln	61,647	6,083	445.00	89,980	....	3,927,559	1,552,867	579,506
Madison	9,000	481	1,101.60	3,644	34,848	522	....	35,334
Mineral	21,033	1,390	27.12	1,561	399,891	....	....	111,017
Powell	1,506	195	77.17	2,344	11,371	9,951	....	7,486
Ravalli	....	605	96.27	16,155	4,260	32,618	491,943	69,448
Sanders	636	212	2.87	3,083	16,672	65,315	....	12,768
Silver Bow	4,935,105	1,768,411	28,343.53	9,758,395	213,940,098	10,347,653	180,290,348	86,311,991
	5,086,706	1,793,899	32,675.39	10,053,994	215,587,957	15,550,225	185,851,604	88,109,646

By kinds of concentrates.

	Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value of concentrates.
Dry or siliceous	429	1,118.35	2,705	7,211	102	....	$27,325
Copper	1,492,104	22,981.51	7,263,678	213,185,020	....	....	64,659,851
Lead	8,818	1,748.36	181,721	28,095	6,279,655	....	733,600
Zinc	285,621	6,203,06	2,520,460	2,275,544	8,017,658	182,958,601	22,177,608
Copper-lead	515	152.35	12,812	40,414	156,388	....	38,188
Lead-zinc	6,178	413 76	63,138	26,073	1,038,422	2,768,138	439,351
Copper-lead-zinc	234	58.00	9,480	25,600	58,000	124,865	33,723

Mine production of metals from Montana crude ore shipped to smelters in 1917.

By counties.

County.	Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
	Short tons	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds*	
Beaverhead	4,129	569.48	123,795	240,794	1,022,258	15,918	$269,053
Broadwater	6,632	2,436.71	17,215	778,937	328,200	15,363	306,998
Cascade	6,782	211,66	204,178	1,023	1,295,063	....	284,272
Deer Lodge	52,179	22,087.42	20,800	186,680	....	....	524,690
Fergus	11	19.54	193	185	2,220	....	805
Gallatin	18	....	3	3,627	....	....	992
Granite	20,958	5,500.46	445,562	419,983	57,067	....	600,411
Jefferson	18,927	3,173.62	160,995	188,771	1,691,049	152,784	410,813
Lewis and Clark	6,717	6,277.26	54,398	25,614	784,911	....	249,083
Madison	2,131	2,398.63	21,647	42,164	413,054	....	114,455
Meagher	873	.38	634	80,871	26,994	....	24,931
Mineral	1,532	82.49	5,554	118,484	60,028	197,595	63,945
Missoula	288	9.21	593	35,286	41,394	....	13,871
Park	153	102.38	1,001	1,154	38,229	....	6,543
Powell	239	142.55	6,227	7,488	43,428	....	13,859
Sanders	368	9.23	8,495	63,443	68,568	....	30,408
Silver Bow	381,086	4,610.22	1,509,318	41,718,253	4,800	26,067	12,731,134
	503,023	47,631.24	2,580,608	43,912,757	5,877,283	407,727	15,646,263

By kinds of ore.

	Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
Dry or siliceous	99,817	39,081.31	713,086	529,440	258,958	....	$1,562,271
Copper	380,130	4,331.85	1,416,880	43,237,494	820	....	13,060,962
Lead	20,402	4,116.60	360,124	25,279	4,623,358	....	786,351
Zinc	475	30.36	4,425	4,283	32,389	194,214	28,040
Copper-lead	1,799	71.12	82,935	116,261	916,794	....	180,392
Lead-zinc	400	....	3,158	....	44,964	213,513	28,247

PRODUCTION BY COUNTIES.

GENERAL FEATURES.

The following tables show the mine production of each metal, by counties, with its total value in 1917, the production of ore and its average value per ton by counties in 1916 and 1917, and the statistics of placer mines in 1916 and 1917. They are followed by a review of the mining industry for each county and each producing mining district.

Mine production of gold, silver, copper, lead, and zinc in Montana in 1917.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total Value.	Quantity.	Value.
	Quantity.	Value.	Quantity.	Value.			
	Fine oz.		*Fine oz.*			*Fine oz.*	
Beaverhead	27.82	$575	1,734.09	$35,847	$36,422	139,303	$114,786
Broadwater	238.54	4,931	2,634.40	54,458	59,389	17,352	14,298
Cascade			220.35	4,555	4,555	204,178	168,243
Deer Lodge			22,087.44	456,588	456,588	20,817	17,153
Fergus			13,004.89	268,835	268,835	2,979	2,455
Gallatin						3	2
Granite	634.82	13,123	5,598.06	115,722	128,845	445,806	367,344
Jefferson	35.94	743	5,256.58	108,663	109,406	324,686	267,541
Lewis and Clark	300.55	6,213	41,908.04	866,316	872,529	156,107	128,632
Lincoln	1.11	23	1,007.17	20,820	20,843	90,137	74,273
Madison	20,006.45	413,570	4,215.06	87,133	500,703	37,967	31,285
Meagher	29.95	619	.38	8	627	638	526
Mineral	340.13	7,031	109.61	2,266	9,297	7,125	5,871
Missoula	60.08	1,242	309.21	6,392	7,634	643	530
Park	12.43	257	111.94	2,314	2,571	1,004	827
Phillips			15,703.88	324,628	324,628	131,341	108,225
Powell	686.63	14,194	302.93	6,262	20,456	8,719	7,185
Ravalli	40.20	831	96.27	1,990	2,821	16,159	13,315
Sanders	2.56	53	12.10	250	303	11,578	9,540
Silver Bow	176.96	3,658	33,240.54	687,143	690,801	11,511,600	9,485,558
	22,594.17	467,063	147,552.94	3,050,190	3,517,253	13,128,142	10,817,589

County.	Copper.		Lead.		Recoverable zinc content.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Beaverhead	266,634	$72,791	1,515,521	$130,335	15,918	$1,624	$355,958
Broadwater	931,359	254,261	328,200	28,225	15,363	1,567	357,740
Cascade	1,023	279	1,295,063	111,375			284,452
Deer Lodge	186,680	50,964					524,705
Fergus	245	67	4,595	395			271,752
Gallatin	3,627	990					992
Granite	419,983	114,655	57,087	4,909			615,753
Jefferson	1,215,385	331,800	2,455,350	211,160	3,638,085	371,085	1,290,992
Lewis and Clark	28,805	7,864	1,199,868	103,189	31,145	3,177	1,115,391
Lincoln			3,927,559	337,770	1,552,867	158,392	591,278
Madison	77,012	21,024	428,999	36,894			589,906
Meagher	80,871	22,078	26,994	2,322			25,553
Mineral	518,375	141,516	60,028	5,162	197,595	20,155	182,001
Missoula	35,286	9,633	41,394	3,560			21,357
Park	1,154	315	38,229	3,288			7,001
Phillips							432,853
Powell	18,859	5,149	53,379	4,591			37,381
Ravalli	4,260	1,163	32,618	2.805	491,943	50,178	70,282
Sanders	80,115	21,872	133,883	11,514			43,229
Silver Bow	270,592,901	73,871,862	10,352,453	890,311	180,316,415	18,392,274	103,330,806
	274,462,574	74,928,283	21,951,220	1,887,805	186,259,331	18,998,452	110,149,382

Ore sold or treated, mines producing, and average value per ton of ores in Montana in 1916 and 1917.

County.	Ore sold or treated, 1917 (short tons).		Number of deep mines producing.		Average value per ton.[a]		Average value per ton in gold and silver.[a]	
	Quantity.	Increase or decrease.	1916	1917	1916	1917	1916	1917
Beaverhead	11,730	+ 9,070	23	35	$65.54	$30.30	$24.26	$12.84
Broadwater	11,144	+ 3,816	13	37	35.39	31.66	11.43	6.17
Cascade	6,791	+ 4,786	17	34	59.24	41.88	35.63	25.45
Deer Lodge	52,180	− 13,536	13	14	12.34	10.05	11.64	9.08
Fergus	38,144	− 28,091	12	9	6.80	7.12	6.67	7.11
Gallatin	18	− 7	1	2	14.68	55.11	.04	.11
Granite	21,121	− 5,233	31	33	26.38	28.52	21.12	22.86
Jefferson	67,632	+ 13,301	61	75	10.76	19.08	3.82	5.56
Lewis and Clark	77,659	+ 5,217	46	77	11.58	14.28	11.30	12.81
Lincoln	62,277	+ 61,934	4	2	25.70	9.49	23.17	1.53
Madison	14,520	− 9,574	85	97	10.65	11.97	8.35	7.98
Meagher	873	− 1,129	5	7	29.16	28.56	.10	.61
Mineral	22,565	− 22,472	3	6	14.47	7.75	1.12	.36
Missoula	688	− 43	5	8	20.93	29.23	7.02	10.06
Park	165	+ 133	2	6	30.22	40.87	17.09	19.03
Phillips	223,350	− 36,530	3	2	2.03	1.94	2.03	1.94
Powell	2,145	+ 1,279	18	14	37.80	10.78	23.00	6.24
Ravalli	12,100	− 7,900	1	1	4.82	5.74	1.13	1.26
Sanders	1,004	+ 495	7	8	64.54	43.00	11.43	9.75
Silver Bow	5,681,058	− 1,528,777	43	51	17.69	18.19	1.50	1.79
	6,307,164	− 1,553,261	393	518	16.94	17.39	1.87	2.20

[a] Value per ton, placer product excluded.

Number and production of producing placer mines in Montana in 1916 and 1917.

County.	1916						1917					
	Hydraulic, dry, and sluicing.	Dredging.	Drift.	Gold.	Silver.	Total value.	Hydraulic, dry, and sluicing.	Dredging.	Drift.	Gold.	Silver.	Total value.
					Fine ounces.						*Fine ounces.*	
Beaverhead	4	....	......	$740	3	$742	2	....	......	$575	2	$577
Broadwater	6	....	......	3,424	31	3,444	6	....	......	4,931	41	4,965
Granite	8	....	1	4,478	50	4,511	6	....	......	13,123	176	13,268
Jefferson	5	....	......	970	10	977	9	....	......	743	12	753
Lewis and Clark	17	....	2	6,638	52	6,672	15	....	2	6,213	56	6,259
Lincoln	5	....	......	1,493	6	1,497	1	....	......	23	....	23
Madison	7	1	......	644,766	4,869	647,970	5	1	......	413,570	3,136	416,154
Meagher	1	....	......	48	....	48	2	....	......	619	4	622
Mineral	15	1	2	12,273	29	12,292	16	....	......	7,031	10	7,039
Missoula	10	....	......	2,492	5	2,495	5	....	......	1,242	3	1,245
Park	....	....	1	543	3	545	3	....	......	257	1	258
Phillips	1	....	......	101	2	102	....	....	......	....	....	....
Powell	18	....	1	22,738	145	22,834	16	....	1	14,194	84	14,263
Ravalli	4	....	1	15,981	46	16,011	3	....	......	831	4	834
Sanders	2	....	......	212	....	212	1	....	......	53	....	53
Silver Bow	7	....	......	6,262	91	6,322	5	....	......	3,658	22	3,676
	110	2	8	723,159	5,342	726,674	95	1	3	467,063	3,551	469,989

BEAVERHEAD COUNTY.

Mine production in Beaverhead County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead	Recoverable zinc content.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	27	2,660	$5,651	90,616	226,132	785,308	....	$175,091
1917	37	11,730	36,422	139,303	266,634	1.515,521	15,918	355,958
Increase, 1917	....	9,070	30,771	48,687	40,502	730,213	15,918	180,867

[a] Includes placer production.

Thirty-five deep-mine operators produced 9,070 tons of ore more than was produced by 23 deep-mine operators in 1916. The total average value per ton decreased from $65.54 in 1916 to $30.30 in 1917, and the gold and silver value decreased from $24.26 to $12.84 a ton. About half of the ore mined in 1917 was of shipping grade and contained $11,772 in gold, 123,795 ounces of silver, 240,794 pounds of copper, and 1,022,258 pounds of lead, valued in all at $269,053, or an average of $65.16 a ton. Ore treated at one gold and silver mill yielded considerable bullion. The largest part of the county output, or 5,820 tons, was dry or siliceous ore; 1,025 tons was copper ore, 3,201 tons was lead ore and old slag, and 1,647 tons was copper-lead ore. Placer bullion contained $575 in gold and 2 ounces of silver, against a yield of $740 in gold and 3 ounces of silver in 1916.

Argenta district.—The greater part of the district output was derived from old slag, which contained principally lead with considerable silver and a little copper and gold. The Tilden property was a producer of lead sulphide ore, containing silver, copper, and gold. There was also some copper ore produced from the Jack Rabbit property.

Bannack district.—Five producers reported 5,450 tons of ore, containing $29,250 in gold, 7,895 ounces of silver, 17,416 pounds of copper, and 7,997 pounds of lead, valued in all at $41,198, or an average value per ton of $7.56. The greater part of the output in tonnage and value of gold and silver was from the Bannack property, equipped with a cyanidation plant which was operated intermittently the early part of the year and closed indefinitely in June. According to letters,[1]

> The equipment of the mine is in good condition, and its milling capacity is 150 tons a day. Over $1,500,000 has been taken out of the property in the past. But this has been an irregular production, owing to the loss from time to time of milling and shipping ore and the delays experienced in recovering the veins. The present discontinuance of operations, however, resulted from the encountering of heavy water in the Priscilla winze, where the ore sampled across 8 feet averaged $40 gold per ton in the vein at the contact of granodiorite and lime. This discovery in the bottom of the Priscilla winze is no doubt a renewal of the old ore bodies separated by a leached zone. It was impossible to overcome the water with the existing pumping and power plants, and a shutdown resulted.
>
> Exclusive of the rich showings in the Priscilla winze, I should estimate, gaging the values from the mill run and from the extensive sampling which has been done from time to time, that at least 17,400 tons of $5.20 gold per ton ore is ready for milling in the upper workings and most of this ore has already

---

[1] Turner, G. D. B., mining engineer, to J. H. McClement, New York. Letter dated Nov. 15. 1917.

been broken and filled in stopes ready to withdraw. Under the present condition of labor and material, I should estimate a net profit on the working of this mill of at least $1.13 per ton, or $18,871.

Some oxidized copper ore was shipped from the Excelsior claim of the Original Bannack Mining Co. and three smaller producers.

Beaverhead district.—Eight deep mines produced 164 tons of ore, containing gold, silver, copper, and lead, having a total value of $13,245, or an average value per ton of $80.76. There was a placer output reported by one producer. The principal producers of copper ore were the Baltic, Dark Horse, and Monument properties. The I. X. L. placer was operated about 30 days during the year and won a small quantity of gold bullion by sluicing.

Big Hole district.—The Montana Oreway property, near Briston, produced siliceous silver ore and some oxidized copper-lead ore. Through small operations of the New Discovery placer a small quantity of gold bullion was produced.

Blue Wing district.—Five operators produced 248 tons, the largest output coming from the New Departure property, which yielded principally silver ore containing gold with a little lead and copper. There were smaller productions from the Kent and Cotton Tail properties.

Bryant district.—The output of 1,918 tons of ore, principally from the Cleopatra, Ariadne, True Fissure, Oneida, Alta, Atlantis, Trapper, and Cleve claims, contained $1,473 in gold, 80,891 ounces in silver, 104,791 pounds of copper, 908,830 pounds of lead, and 15,918 pounds of recoverable zinc, valued in all at $176,518, or an average value per ton of $92.03. All this ore, which included that from the Vermont, Avanca, Copper Bottom, and a small tonnage of old slag from the Hecla, was shipped directly to the smelters.

Camp Creek district.—Some copper ore, containing silver and a little gold, was shipped from the Banner property.

Elkhorn district.—This district was the scene of much active development work during 1917. The Boston Montana Development Co. reported the control of about 2,000 acres of mineral land, known as the Central group and other claims, cut by numerous veins, all said to contain a commercial grade of copper ore on the surface. Two of the largest veins are reported to have been cut at a depth of 1,000 feet by the recently completed double-tracked adit 2,070 feet long. Additional development was made by two crosscuts 2,001 feet and 2,500 feet long, respectively. A concentration mill is planned, and a railroad to the mines, starting from Divide on the Oregon Short Line Railroad, is expected to be built in 1918.

Polaris district.—The Silver Fissure mine yielded an important tonnage of siliceous silver ore, containing a little gold, which was shipped to the copper smelter at Anaconda.

Saginaw district.—An estimated production of 290 tons of oxidized copper ore containing a little silver was reported shipped from the Saginaw group.

Utopia district.—The Indian Queen and the Chief & Ida properties were producers of smelting ore containing copper and a little silver.

Vipond district.—Two producers reported oxidized lead ore containing silver. The principal part of the output was shipped from the Gray Jockey claim directly to the smelter.

BROADWATER COUNTY.

Mine production in Broadwater County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	19	7,328	$82,491	7,223	700,542	46,480	....	$262,784
1917	43	11,144	59,389	17,352	931,359	328,200	15,363	357,740
Increase or decrease, 1917	....	+3,816	−23,102	+10,129	+230,817	+281,720	+15,363	+94,956

[a] Includes placer production.

The production in 1917 of 11,144 tons of ore by 37 operators of deep mines is 3,816 tons more than was produced by 13 operators in 1916. The total average value per ton decreased from $35.39 in 1916 to $31.66 in 1917, and the gold and silver value in this ore from $11.43 to $6.17. The greater part of the ore, or 6,632 tons, was of shipping grade. There were treated at 2 milling plants 4,512 tons of ore, which yielded 261 tons of concentrate, principally a copper product, and some gold and silver bullion. The total output from deep mines of the county was $54,458 in gold, 17,311 ounces of silver, 931,359 pounds of copper, 328,200 pounds of lead, and 15,363 pounds of recoverable zinc, valued in all at $352,775. The yield of placer bullion amounted to $4,931 in gold and 41 ounces of silver, against $3,424 in gold and 31 ounces of silver in 1916.

Backer district.—The Slim Jim and Humming Bird properties were producers of gold bullion containing a little silver, recovered in milling operations from small but rich veins of gold quartz. Some of the work on the Slim Jim property was performed by lessees. Placer gravel in Confederate Gulch, worked by hydraulicking, also yielded some gold and silver bullion.

Beaver district.—Twelve deep-mine operators and 1 placer operator reported the production of 1,027 tons of ore, containing $9,929 in gold, 10,168 ounces of silver, 554 pounds of copper, 269,556 pounds of lead, and 15,363 pounds of recoverable zinc, valued in all at $43,208. The ore produced averaged $41.49 per ton. The principal producer of lead ore of shipping grade was the Hyantha property. Smaller shipments were made from the Little Olga, Mary V., and Joe Dandy properties. The Indian Creek placer produced a small quantity of gold from hydraulic operations.

Cedar Planes district.—Sixteen deep mines and 1 placer reported the production of 4,251 tons of ore, containing $42,010 in gold, 5,858 ounces of silver, 80,388 pounds of copper, and 45,906 pounds of lead. The total value of this output was $72,731. The ore, all of which was of shipping grade, averaged $16.92 a ton. Owing to litigation, the largest producer in the district was practically inactive, and only a small quantity of iron sulphide ore, containing principally gold and a little copper, was shipped early in 1917. The Copper King & Alaska, Jumbo, Mohave, Mountain View, Ruby Silver, Santa Anita, and Little Giant properties were producers. The Crow Creek placer in Charity Gulch was operated about 75 days, yielding a small quantity of gold bullion.

Hellgate district.—The Furnace Creek Oxide Copper Co., operating the Eclipse Argo property, equipped with a 50-ton table concentrator, shipped copper concentrate and copper sulphide ore to the smelter. The ore is mostly chalcopyrite, containing one-tenth of an ounce of silver and a trace of gold per ton.

Park district.—Six deep mines and 3 placers reported an output valued at $2,789 in gold, silver, and lead. The principal producers of lead ore were the Double Standard, Margaret Taylor, Bedford, Boomerang, and Iron Mask properties. Three placers produced $120 in gold and silver bullion. The Metropolitan & Kalamazoo property in the Warm Springs region was also worked.

CASCADE COUNTY.

Mine production in Cascade County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	17	2,005	$6,533	98,651	3,916	635.169	19,106	$118,795
1917	34	6,791	4,555	204,178	1,023	1,295,063	....	284,452
Increase or decrease, 1917	....	+4,786	−1,978	+105,527	−2,893	+659,894	−19.106	+165,657

Thirty-four deep mines in 1917 produced 4,786 tons more ore than 17 operators in 1916. The total average value per ton of the ore decreased from $59.24 in 1916 to $41.88 in 1917, and the gold and silver value per ton from $35.63 to $25.45. The total output of the county amounted to $284,452. The greater part of the ore, or 3,665 tons, was dry or siliceous in character, and the remainder, 3,126 tons, was lead ore.

Montana district.—Thirty-one producers reported an output of 6,488 tons of ore, containing $4,555 in gold, 196,426 ounces of silver, 534 pounds of copper, and 1,215,994 pounds of lead, valued in all at $271,131, or an average value per ton of $41.79. All the ore, with the exception of 9 tons which yielded a little gold bullion, was of shipping grade. Over half of the output, consisting of sulphide ore containing principally silver and a low percentage of lead, came from the Galt property. Other producers of importance were the Tom Hendricks, Liberty, Queen of the Hills, Ripple, Silver Belt, B. & M., Equator, Wright & Edwards, Florence, and Broadwater properties.

Running Wolf Creek district.—Three deep-mine producers shipped to the smelters from Stanford, on the Great Northern Railway, 303 tons of ore, containing 7,752 ounces of silver, 489 pounds of copper, and 79,069 pounds of lead, valued in all at $13,321, or an average value per ton of $43.96. Most of this output, consisting of oxidized lead ore, was from the Mountainside property. Ore was also produced from the S. W. Scott, Romer Sunrise, Dry Wolf, and Charles Martin claims.

DEER LODGE COUNTY.

Fourteen deep-mine operators reported the production of 52,180 tons of ore in 1917, a decrease of 13,536 tons. The total value per ton decreased from $12.34 in 1916 to $10.05 in 1917, and the gold and silver value per ton from $11.64 to $9.08. The largest part of the ore, or 52,133 tons, was highly oxidized ore of shipping grade, containing principally gold and valuable at the smelters chiefly for fluxing. No placer production was reported in 1917.

Fisher Creek district.—The Little May claim was a producer of sulphide copper ore containing a little silver.

French Gulch district.—The placers and lode mines of the Boston Montana Development Co. were idle. All of the work by this mining company was performed in the Elkhorn district of Beaverhead County.

Georgetown district.—Eleven producers reported 52,085 tons of ore, containing $456,523 in gold, 20,218 ounces of silver, and 178,262 pounds of copper, valued in all at $521,849, or an average value per ton of $10.02. The principal part of the output was from the Southern Cross mine, which produces an oxidized iron ore, containing gold with a little silver and copper. Similar ore was produced from the Holdfast, New Year, and Oro Fino properties.

Oro Fino district.—The Independence mine yielded a small quantity of oxidized copper ore, which was shipped directly to the smelter. There was also a small output of silver ore containing a little gold from the March property.

FERGUS COUNTY.

Mine production in Fergus County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	12	66,235	$432,687	13,920	8,280	93,351	$450,324
1917	9	38,144	268,835	2,979	245	4,595	271,752
Decrease, 1917		28,091	163,852	10,941	8,035	88,756	178,572

Nine producers in 1917, against 12 producers in 1916, reported a large decrease. All the ore, with the exception of 11 tons, was of milling grade and yielded gold and silver bullion and a little lead concentrate. The crude shipping ore contained gold, silver, copper, and lead and was valued at $805, or an average of $73.18 per ton.

Cone Butte district.—The Big Chicago property was a producer of gold ore, which was treated in its 15-ton cyanidation plant.

North Moccasin district.—Owing to the severe weather conditions in the district, open-cut mining was possible for only eight minths during 1917. Gold ore was produced from the North Moccasin and Kendall properties, operated by the Barnes King Development Co., whose annual report[1] gives a yield of 26,790 tons of ore, averaging

---

[1] Barnes King Development Co. Ann. Rept. for year ending Dec. 31, 1917.

$8.53 per ton in gold and silver, against 33,715 tons averaging $8.65 in 1916. From the Kendall property, which was leased during 1917, the production of ore was 7,923 tons, averaging $2.95 a ton in gold and silver. This output is only a little more than half that of 1916, when 14,918 tons were mined and milled, averaging $2.50 a ton in gold and silver.

Warm Springs district.—From the Maginnis and Cumberland properties some gold ore was treated in cyanidation plants.

GALLATIN COUNTY.

The Leonard mine and one other property in an unorganized mining district produced silver-bearing copper ore, valued at $992 at the smelter.

GRANITE COUNTY.

Mine production in Granite County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	40	26,354	$134,002	649,328	493,349	75,709	89,063	$699,782
1917	39	21,121	128,845	445,806	419,983	57,087	....	615,753
Decrease, 1917	....	5,233	5,157	203,522	73,366	18,622	89,063	84,029

[a] Includes placer production.

Thirty-three producers mined 21,121 tons of ore, or 5,233 tons less than was mined by 31 producers in 1916. The total average value per ton increased from $26.38 in 1916 to $28.52 in 1917, and the gold and silver value per ton from $21.12 to $22.86. The crude ore shipped, 20,958 tons, contained gold, silver, copper, and lead and had an average value per ton of $28.65. There were 163 tons of ore which yielded bullion at gold and silver mills. Six placer operators reported the yield of $13,123 in gold and 176 ounces of silver, against $4,478 in gold and 50 ounces of silver from 9 placers in 1916.

Alps district.—Some gold ore from the Rainy Day property treated in a 5-ton amalgamation mill produced a small quantity of gold bullion.

First Chance district.—The Nancy Hanks property, worked by lessees in 1917, produced a considerable quantity of gold ore containing silver and a little copper. The Mountain group was operated during the greater part of the year, yielding copper ore of shipping grade, and the Alabama placer, situated at Summit, 2 miles east of Garnet, yielded a small quantity of gold from sluicing operations.

Flint Creek district.—Eighteen producers reported the output of 16,810 tons of ore, containing $39,759 in gold, 427,623 ounces of silver, 201,064 pounds of copper, and 41,652 pounds of lead, valued in all at $450,593, or an average value per ton of $26.81. All this ore was shipped directly to the smelter, with the exception of 2 tons, which produced a little silver bullion. The principal part of the output was silver ore with a little gold and copper from the

Granite-Bimetallic mine. From the Hope mine, operated by the Philipsburg Mining Co., copper ore and some lead ore containing silver and gold was shipped. There were smaller productions from the Hobo group, Londonderry, Swastika, and White Horse claims. Shipments of manganese ore from various properties were made during 1917 to manufacturers of steel in the Eastern States.

Rock Creek district.—The principal work done was on the Basin placers, which were worked by hydraulicking methods and yielded gold and silver bullion.

South Boulder district.—Ten deep mines reported the production of 730 tons of ore, containing $1,327 in gold, 5,511 ounces of silver, 39,257 pounds of copper, and 10,397 pounds of lead, valued in all at $17,479, or an average value per ton of $23.94. The placer output made by 2 producers was valued at $373. Lessees milled some gold ore from the Royal Gold property and produced a small quantity of gold bullion. The Royal Basin, Brooklyn, Kink & Copper Queen, and Bay View properties were producers, principally of copper ore. The Montana placer, on Princeton Creek, and the Lulu placer, in Wilson Gulch, were producers of gold bullion.

JEFFERSON COUNTY.

Mine production in Jefferson County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	66	54,331	$100,412	164,703	852,857	679,760	898,348	$585,872
1917	84	67,632	109,406	324,686	1,215,385	2,455,350	3,638,085	1,290,992
Increase, 1917	....	13,301	8,994	159,983	362,528	1,775,590	2,739,737	705,120

[a] Includes placer production.

Seventy-five deep-mine producers in 1917 reported 13,301 tons of ore more than was reported by 61 producers in 1916. The total average value per ton increased from $10.76 in 1916 to $19.08 in 1917, and the gold and silver value per ton in this ore from $3.82 to $5.56. Most of the ore produced, or 48,479 tons, was of milling grade and yielded 14,872 tons of concentrates, which contained $42,795 in gold, 162,039 ounces of silver, 1,025,144 pounds of copper, 749,275 pounds of lead, and 3,485,301 pounds of recoverable zinc, valued in all at $876,117, or an average value per ton of $58.91. There were 18,927 tons of shipping ore, containing gold, silver, copper, lead, and zinc, valued in all at $410,813, or an average value per ton of $21.71. The greater part of the ore output (30,521 tons) was classified as copper ore, and 17,974 tons were lead-zinc ore. The remainder of the output consisted of 5,792 tons of dry or siliceous ore, 10,969 tons of lead ore, 363 tons of zinc ore, 1,001 tons of copper-lead ore, and 1,012 tons of copper-lead-zinc ore. The production of 9 placer operators amounted to $743 in gold and 12 ounces of silver, against a production of $970 in gold and 10 ounces of silver in 1916.

Amazon district.—From the Australian claim a small tonnage of silver ore and some low-grade lead ore was shipped directly to the smelter. There was also a small shipment from the Phoenix property.

Boulder district.—Altogether 2,266 tons of ore were produced by 5 deep mines in the district. The total output contained $6,047 in gold, 24,753 ounces of silver, 52,001 pounds of copper, 191,726 pounds of lead, and 124,865 pounds of zinc, valued in all at $69.683, or an average value per ton of $30.83. The larger part of this ore, or 1,921 tons, was milled and produced copper-lead-zinc concentrate. There were also 345 tons of crude shipping ore produced. The Baltimore property was the largest producer, yielding an ore from which a concentrate containing copper, lead, zinc, and silver was saved at the Washoe works near Anaconda. Copper-lead ore from the Bland & Weaver property was treated in its 40-ton concentration plant situated in the district. There was also a small output of gold bullion reported by 2 placer operators.

Cataract district.—Twenty-three deep mines in 1917 produced 22,183 tons of ore, containing $51,153 in gold, 152,977 ounces of silver, 186,043 pounds of copper, 1,063,054 pounds of lead, and 3,509,184 pounds of recoverable zinc, valued in all at $677,356, or an average value per ton of $30.53. The placer output reported by a few producers was small. One property produced most of the ore, which was milled and yielded lead and zinc concentrates. The ore of shipping grade amounted to 4,215 tons. The largest producer was the Comet mine, from which the zinc concentrates were shipped to the electrolytic zinc works at Great Falls and the lead concentrates to the lead plant at East Helena. There were also considerable shipments of crude ore from the West Rumley and the Hope, and smaller lots from the Crystal, John T., Last Chance, Montana, Solar Pearl, Uncle Sam, and Ruby properties. The Aaron placer on Overland Creek, 11 miles from Basin, produced a small quantity of gold.

Colorado district.—Eighteen producers reported 35,945 tons of ore, containing $23,620 in gold, 128,696 ounces of silver, 895,792 pounds of copper, 910,160 pounds of lead, and 4,036 pounds of recoverable zinc, valued in all at $452,903, or an average value per ton of $12.60. Most of this ore, or 28,593 tons, was milled and produced copper concentrate containing silver and gold. The Bertha mine was the principal producer of milling ore. The ore of shipping grade amounted to 7,259 tons, containing 1,043.73 ounces of gold, 78,578 ounces of silver, 20,236 pounds of copper, and 900,336 pounds of lead. Most of this crude ore was shipped from the Angelica property, with smaller quantities from the Alta and the Blue Bird.

Elkhorn district.—There were 5,910 tons of ore and a small quantity of old tailings reported by 8 operators. The total output contained $21,260 in gold, 9,113 ounces of silver, 17,222 pounds of copper, and 105,235 pounds of lead, valued in all at $42,521, or an average value per ton of $7.19. The principal part of the ore shipped was from the Golden Curry mine, which yielded an oxidized iron ore containing a little gold, silver, and copper. Other shipments of importance were made by lessees on the Elkhorn Queen and the Holter claims. The Fortune Teller placer, on Wilson Creek, yielded gold by sluicing.

Homestake district.—The Black Sheep and Homestake properties were reported as small shippers of crude ore to the smelter.

Lump Gulch district.—Five producers reported the shipment of 79 tons of ore, valued for its content of gold, silver, copper, and lead at $4,256, or an average value per ton of $53.87. The output of gold bullion from 2 placers was valued at $336. The deep mines operated were the Bell, White Pine, Two Dot, and Capital Consolidated. The Lump Gulch placer, 9 miles from Clancey, yielded a small quantity of gold bullion during the construction of 1,400 feet of sluice boxes.

Whitehall district.—All the ore produced in the district was of shipping grade and amounted to 972 tons, containing $3,979 in gold, 3,595 ounces of silver, 63,301 pounds of copper, and 162,774 pounds of lead, valued in all at $38,220, or an average value per ton of $39.32. Most of the ore was from the property of the Butte Cardwell Mining Co. There were smaller shipments made from the Eighty Acre, Parrot, Golden Sunlight, and Milburn properties.

LEWIS AND CLARK COUNTY.

Mine production in Lewis and Clark County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
Placers:		*Short tons.*		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	19	....	$6,638	52	....	....	....	$6,672
1917	17	....	6,213	56	....	....	....	6,259
Deep mines:								
1916	46	72,442	751,476	101,583	33,102	92,285	43,318	838,634
1917	77	77,659	866,316	156,051	28,805	1,199,868	31,145	1,109,132
Increase or decrease, 1917	....	+5,217	+114,415	+54,472	−4,297	+1,107,583	−12,173	+270,085

The output of ore reported by 77 producers was 5,217 tons greater than was produced by 46 operators in 1916. The total average value per ton increased from $11.58 in 1916 to $14.28 in 1917, and the gold and silver value from $11.30 to $12.81. Ores sent to gold and silver mills, aggregating 61,141 tons, were treated principally by cyanidation and yielded bullion containing $727,132 in gold and 85,039 ounces of silver and having an average value per ton of $13.04. In addition to the ores yielding bullion, 4,839 tons of ore produced 1,375 tons of concentrates, containing gold, silver, lead, zinc, and a little copper. Crude shipping ore aggregated 6,717 tons and contained $129,762 in gold, 54,398 ounces of silver, 25,614 pounds of copper, and 784,911 pounds of lead, valued in all at $249,083, or an average value per ton of $37.08. Most of the ore mined (69,848 tons) was dry or siliceous in character. There were also produced 148 tons of copper ore, 7,405 tons of lead ore, and 258 tons of lead-zinc ore. The placer output of 17 producers amounted to $6,213 in gold and 56 ounces of silver, against $6,638 in gold and 52 ounces of silver in 1916.

Bald Butte district.—Three producers shipped gold and silver bullion and some concentrate containing gold and silver, recovered from 161 tons of ore and 4,962 tons of old tailings. The tailings were treated in a cyanidation plant, and the ore was treated by amalgamation. The Albion and Eureka properties were the producers of crude ore, and the tailings were from an old mill situated in the district.

Big Blackfoot district.—The Lockey claim yielded a small quantity of gold bullion from crude ore treated in an arrastre.

Dry Gulch district.—A small shipment of crude lead ore, containing silver, was made from the Lady Alice property. The New York Gulch placer produced some bullion, which, with that from the operations carried on by several Chinamen, yielded gold valued at $2,422 and 19 ounces of silver.

Gladstone district.—The Copper Lode mine was a producer of sulphide copper ore, containing silver.

Gould district.—A small quantity of gold, probably from operations in 1916, was reported from one property in the district.

Greenhorn district.—Crude ore of shipping grade, containing silver, was produced from the Stem Winder and Far West properties, and gold ore with a little lead and silver was produced from the Umatilla and Pipe Line claims. The Evans & Jones placer was operated for four months by drift mining and yielded a small quantity of gold.

Helena district.—Crude ore shipped amounting to 2,045 tons and 4 tons treated by amalgamation were reported by 14 operators. The total output of the district, containing gold, silver, copper, and lead, was valued at $67,145, or an average value per ton of $32.80. The greater part of the ore was produced from the Helena mine, operated by the Helena Mining Bureau, which shipped a sulphide ore of lead and iron containing considerable silver and some gold. The Rock Rose & Looby, Horn Lode, and Copper Queen properties shipped small quantities of ore. Various small operations carried on with rockers and bullion from the Humboldt placer, in Grizzly Gulch, yielded $760 in gold and 6 ounces of silver. The Northwestern Metals zinc plant, which was built in 1915 and proved a failure, was equipped for concentration and operated as a custom plant by the New York Montana Testing & Engineering Co. in 1917. Ore from the Valley Forge dumps at Rimini and manganese ore from Philipsburg and Butte were treated. The mill has a capacity of 50 to 80 tons of ore daily and is equipped with 2 crushers, 2 sets of rolls, 1 Colorado ball mill, 8 Wilfley tables, and 4 Hartz jigs.

Lincoln district.—From the Mike Horse mine some lead ore containing silver and a little copper and gold was shipped to the smelter. The Harvey and Old Billy Williams placers yielded gold by sluicing. It is possible to work these properties only about six months of the year.

Ottawa district.—Fifteen producers reported 56,565 tons of ore, containing $691,160 in gold, 82,694 ounces of silver, 3,287 pounds of copper, and 91,290 pounds of lead, valued in all at $768,048, or an average value per ton of $13.58. The greater part of this output was treated at cyanidation plants. The 400 tons shipped directly to smelters contained 5.42 ounces of gold, 2,818 ounces of silver, 3,287 pounds of copper, and 91,290 pounds of lead. Most of the milling ore was from the Shannon and Piegan-Gloster properties. There was also an important tonnage of ore from the Drumlummon mine treated in the mill belonging to the St. Louis Mining Co.

At the Piegan-Gloster mine[1] 20,525 tons of ore were mined and treated by the cyanidation process and yielded bullion containing 8,381.65 ounces of gold and 60,008.86 ounces of silver. According to the report of the company,

> Development work was mostly confined to the ground adjoining the Gloster workings, and production came from ore shoots found west of the old stopes.
>
> The 400 level was driven west 657 feet on veins, and three ore bodies were found. These were short and did not go up far enough to justify the driving of the 360 level west.
>
> The 500 level was driven 560 feet west, but values under the ore shoots found on the 400 level were found too low grade to stope, except for a distance of 40 feet below the 400. There are three short ore shoots still ahead of the 500 face, and it is likely that they will be found as one longer shoot when opened on this level.
>
> At the eastern end of the mine crosscuts and drifts were entirely unproductive, although 250 feet of vein was explored which lines up with the Gloster vein on strike.

The Shannon became the property of the Barnes King Co. in 1917 and produced 32,359 tons of ore, which was treated by the cyanidation process and yielded 23,011.07 ounces of gold and 30,211.72 ounces of silver. The ore from the Piegan-Gloster and Shannon mines was treated at the Gloster mill. The company report continues as follows:

> Sinking from the 400 level to the 500 was begun in February, and drifts started on the latter level in April. In sinking this lift the shaft was in the vein but apparently passed through the ore shoot halfway down, and drifting east on the 500 level has failed to show values. In drifting west the vein was rich, but the shoot was only a little more than 100 feet long and about the width of the drift. Values were approximately $50 per ton. * * *
>
> Sinking of the shaft to the 650 was started in November and 85 feet of the 150 completed by the end of the year.

In Uncle Ben Gulch, 9 miles from Marysville, lessees operated the Sandburn & Goodenough placer by sluicing and hydraulicking.

Owyhee district.—Three producers reported 47 tons of ore, valued at $2,186, or an average value per ton of $46.51 for its content of gold, silver, and copper. The producers were the Grand View, D. & D., and McRea claims.

Poorman district.—A small quantity of bullion was produced from sluicing gravel of one placer.

Scratch Gravel district.—Nine producers reported 3,629 tons of ore, all of which was shipped to the smelters and contained $117,028 in gold, 15,598 ounces of silver, 2,420 pounds of copper, and 109,684 pounds of lead, valued in all at $139,975, or an average value per ton of $38.57. The principal part of the production was from the Franklin mine, and some ore came also from the Scratch Gravel gold mine. Both properties produced a silver-bearing gold ore, which was smelted. There were also large shipments from the Julia and Katie claims.

Springhill district.—The Skelly Gulch and St. Louis placers, situated 9 miles from Austin, yielded a small quantity of gold bullion by drifting and sluicing.

Stemple district.—Eight operators produced 1,544 tons of ore, containing gold, silver, and copper, valued at $16,855. The larger part of the ore was estimated as the output of one property, which produced gold bullion recovered by amalgamation. There was also some ore treated by cyanidation. Only 35 tons of crude ore, a part of which was from the Bachelor property, were shipped directly to the smelter. There were smaller shipments from the Klondyke and Rover claims.

---

[1] Barnes King Development Co. Ann. Rept. for year ending Dec. 31, 1917.

Ten Mile district.—The Stanton and Merritt were the only mining claims from which ore was shipped in 1917. The former property yielded milling ore, which was shipped to the concentrating works near Helena, and some zinc ore was shipped to eastern zinc furnaces.

Unionville district.—From a clean-up of the Whitlatch mine and mill, some bullion and crude smelting ore containing gold and silver were shipped.

Vaughn district.—Seven producers reported 6,644 tons of ore, which with bullion from 2 placers contained $16,829 in gold, 15,110 ounces of silver, 1,071 pounds of copper, and 219,413 pounds of lead, valued in all at $48,441. Most of the output was milled and yielded bullion at gold and silver mills and a lead concentrate at a custom milling plant. The principal part of the bullion production came from the Porphyry Dike and San Juan properties, and the milling ore was from the mine dump of the Valley Forge property. There was a small output of shipping ore and milling ore from the R. E. Lee and Caplice Extension properties. The Perseverance and Tucker Gulch placers yielded some gold bullion during a short season of operation.

Wolf Creek district.—The production was 85 tons of ore, containing gold, silver, copper, and lead, with a total average value per ton of $37.21. The producers were the Silver Lode, King Bear, Algoma, Hanks, and Mountain View properties.

LINCOLN COUNTY.

Two deep-mine operators reported 62,277 tons of ore, valued in all at $591,255, or an average value per ton of $9.49. All of this ore was milled, 630 tons yielding gold and silver bullion by amalgamation and the remainder producing concentrates, containing gold, silver, lead, and zinc. Only one placer operator reported production, against 5 placer operators producing $1,493 in gold and 6 ounces of silver in 1916.

Libby district.—Gold and silver bullion and tungsten concentrates were produced from ore treated from the Rose Consolidated property, which is equipped with an amalgamation and concentration plant. Only one placer producer reported a small quantity of gold. In previous years the placer output has been noteworthy, and it is possible that more gold was produced in 1917 than was reported to the Survey.

Troy district.—The Snowstorm Consolidated, operating the Banner & Bangle property, treated a large quantity of ore, yielding lead and zinc concentrates. The mill producing these concentrates is a new one situated on Callahan Creek, 1 mile from Troy, completed and started May 1, 1917. It has an equipment for treating 400 tons of ore daily, consisting of a gyratory crusher, 4 sets of rolls, three 8-foot Hardinge mills, 2 Richards-Janney classifiers, 7 Isbell vanners, and 11 Wilfley and 15 Diester tables. Experimental work with oil flotation is under way.

MADISON COUNTY.

Mine production in Madison County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
Placers:		*Short tons.*		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	8	....	$644,766	4,869	....	....	....	$647,970
1917	6	....	413,570	3,136	....	....	....	416,154
Deep mines:								
1916	85	24,094	175,464	39,046	116,744	383,557	2,642	256,694
1917	97	14,520	87,133	34,831	77,012	428,999	....	173,752
Increase or decrease, 1917	....	−9,574	−319,527	−5,948	−39,732	+45,442	−2,642	−314,758

Ninety-seven deep-mine operators in 1917 reported the production of 14,520 tons of ore, a decided decrease from the output of 1916. The total average value per ton increased from $10.65 in 1916 to $11.97 in 1917, but the gold and silver value per ton decreased from $8.35 to $7.98. The larger part of the ore (9,000 tons) was treated at concentration mills and yielded 481 tons of concentrates containing $22,772 in gold, 3,644 ounces of silver, 34,848 pounds of copper, and 522 pounds of lead, valued in all at $35,334, with an average value per ton of $73.46. There were 2,843 tons of ore treated at gold and silver mills, yielding bullion containing $14,470 in gold and 8,751 ounces of silver and having an average value per ton of $7.63. There were 2,131 tons of ore shipped, containing $49,584 in gold, 21,647 ounces of silver, 42,164 pounds of copper, and 413,054 pounds of lead, valued in all at $114,455, or an average value per ton of $53.71. Of the ore mined, 10,167 tons were classified as dry or siliceous ore, 3,291 tons as copper ore, and 1,062 tons as lead ore. Placer bullion reported by 6 producers amounted to $413,570 in gold and 3,136 ounces of silver, against a placer output by 8 producers of $644,766 in gold and 4,869 ounces of silver in 1916.

Alder Gulch district.—The output of 8 deep mines and 3 placers was valued at $421,393. The ore produced amounted to 267 tons, of which 145 tons were milled, yielding gold and silver bullion, and the remainder of the ore was shipped directly to the smelter. The principal producers were the U. S. Grant, Butte & Virginia, Alameda, Feldspar, Metallic, and Adopted Kid properties. The placer gold came largely from the Conrey property, on which 3 dredges operated during the entire year, yielding a greatly decreased output. During two months of 1917 the Alder Gulch Consolidated placers yielded gold by sluicing.

Havana district.—The Forsythe Development Co., operating the Havana mine, shipped a small quantity of siliceous silver ore containing a little gold. This property is opened by a shaft 300 feet deep. Much of the work in 1917 consisted of cleaning up the old works and dewatering the mine.

Lower Hot Springs district.—The output of 44 tons of ore by 9 producers was valued at $2,875, or an average value per ton of $65.34. The ore contained principally gold and silver, with a small quantity of copper reported from one property. The principal producers were the Badger, Florence, Twin Lake, Josephine, Midnight, and Morning Star.

McCarthy district.—The Windy and Mountain View properties were producers of lead ore, containing silver and a little gold and copper.

Mineral Hill district.—Seven operators reported the production of 2,557 tons of ore, containing $13,229 in gold, 951 ounces of silver, 1,335 pounds of copper, and 2,732 pounds of lead, valued in all at $14,612, or an average value per ton of $5.71. Most of the ore was produced from the Indian Gold property and was treated in an amalgamation and concentration plant, yielding gold and silver bullion and concentrate. There were 57 tons of ore shipped directly to the smelter from the Mountain Chief, Pony, White Pine, Horn Silver, and Wilson properties.

Norwegian district.—Four producers reported the output of 83 tons of ore of shipping grade, valued at $2,487, or an average value per ton of $29.96 for the content of gold, silver, copper, and lead. The producers were the Colorado, Gold Hill, O. K., and Rogers properties.

Rabbit district.—Seven mine operators reported a production of 187 tons of ore, containing gold, silver, copper, and lead, valued at $9,871, or an average value per ton of $52.79. Among the claims producing were the Emma, Marshall, Nez Perce, Rambler, Clifton, and Good Friday.

Ramshorn district.—The North Star mine produced a small quantity of gold ore containing a little copper and silver, and some gold ore was shipped from the Betsy Baker and Gold Coin group. In California Gulch the Camp Bird placer was operated and produced some gold bullion.

Sheridan district.—Ten producers reported 416 tons of ore, containing $5,285 in gold, 1,769 ounces of silver, 368 pounds of copper, and 164,118 pounds of lead, valued in all at $20,957, or an average value per ton of $50.38. A large part of this output was from the Deutschland claim, which yielded lead sulphide ore containing silver and gold. Smaller quantities of similar ore were produced by the Ivey, Silver King, Bay State, and Brandon properties, and gold and silver ore by the Ruby and Tamarack properties.

Silver Star district.—Nine operators reported 144 tons of ore, containing gold, silver, copper, and lead, valued at $4,945, or an average value per ton of $34.34. All of this ore, except 2 tons producing gold and silver bullion, was shipped directly to the smelters. The Edgerton, Hudson, King Fisher, Lean, and Turmoil properties were producers.

Summit district.—Seven producers reported 654 tons, containing $5,012 in gold, 10,535 ounces of silver, 3,923 pounds of copper, and 522 pounds of lead, valued in all at $14,809, or an average value per ton of $22.64. The larger part of the ore was shipped directly to the smelters, and 500 tons of tailing and 42 tons of crude ore yielded gold and silver bullion and a small quantity of lead concentrate. The old tailings were from the Easton Pacific property, operated by lessees in 1917. There was also a small quantity of silver ore shipped to the smelter from this property. Shipping ore was also produced from the Elfleda, Homestake, Copper Glance, and Wild Cat properties. The Mountain Flower and Highland Chief properties yielded milling ore producing bullion and a small quantity of concentrate. A small experimental concentration plant equipped with a crusher and one Isbell vanner was completed in December, 1917. Ores from the Winnetka, St. John, and Moonlight properties will be treated if these ores are found amenable to concentration.

Tidal Wave district.—Ore amounting to 6,973 tons was produced by 25 operators in 1917 and contained $50,546 in gold, 10,026 ounces of silver, 14,633 pounds of copper, and 190,781 pounds of lead, valued in all at $79,209, or an average value per ton of $11.36. The greater part of the ore from the B. & H. property was milled and produced concentrate containing gold, silver, and copper. The remaining part of the output, or 973 tons, was shipped directly to the smelters from the Elenora, Silver Bell, Sunset, Van Meter, Missouri & Texas, Longfellow, Ella, Bay State, High Ridge, and Little Goldie properties.

Upper Hot Springs district.—Three producers reported 49 tons of ore, containing $3,664 in gold, 394 ounces of silver, and 887 pounds of copper, valued in all at $4,230, or an average value per ton of $86.33. The mines producing were the Monitor & Revenue, Galena & Boaz, and Bull Moose.

Washington district.—Gold ore, with a little silver and lead, was shipped from the Lehigh property.

Wilmah district.—Milling ore treated in a 100-ton concentration mill on the Montana-Illinois property yielded copper concentrate containing silver and gold. As the milling plant is driven by water power, it was run only a short time between June and August when there was sufficient water.

MEAGHER COUNTY.

There were 873 tons of ore produced in 1917, which contained copper, silver, lead, and gold, having an average value per ton of $28.56, against an output of 2,002 tons in 1916, having an average value per ton of $29.16. The output of ore in 1917 was made by 7 producers, who reported 830 tons of copper ore and 43 tons of lead ore. The placer production reported by 2 operators amounted to $619 in gold and 4 ounces of silver, against $48 in gold in 1916.

Castle Mountain district.—The Copper Top mine and the Vandor property yielded copper ore containing silver, and the Yellowstone and Skidoo mines a small quantity of silver-lead ore. The total output was shipped directly to the smelters.

Diamond district.—One placer was productive of a small quantity of gold.

Musselshell district.—The principal producer was the Copperopolis mine, yielding silver-bearing copper ore. There was also a small output of similar ore from the Virginia & Southern Cross and the Blue Bird properties. From the operation of one placer, a few ounces of gold was reported.

MINERAL COUNTY.

Six producers in 1917 reported 22,565 tons of ore, containing $2,266 in gold, 7,115 ounces of silver, 518,375 pounds of copper, 60,028 pounds of lead, and 197,595 pounds of zinc, valued in all at $174,962, or an average value per ton of $7.75. This output consisted largely of copper ore (22,076 tons), most of which was concentrated and yielded a concentrate containing copper with some silver and gold. The crude ore shipped aggregated 1,532 tons and contained $1,705 in gold, 5,554 ounces of silver, 118,484 pounds of copper, 60,028 pounds of lead, and 197,595 pounds of recoverable zinc, valued in all at $63,945, or an average value per ton of $41.74. The placer bullion reported by 16 producers amounted to $7,031 in gold and 10 ounces of silver, against a production of $12,273 in gold and 29 ounces of silver reported by 18 producers in 1916.

Cedar Creek district.—Ore produced from the Amador mine, operated by the Intermountain Copper Mining Co., yielded at its milling plant a considerable output of concentrate containing copper, silver, and gold. There was also some copper ore, which was shipped directly to a smelter in British Columbia. The mill is a 120-ton concentrator in which oil flotation was used. From the operations of 16 placers $7,031 in gold and 10 ounces of silver were produced. The principal part of the output was from the Cedar Creek Co.'s placers operated by hydraulic mining. The dredge, which was formerly on this ground, has been moved outside of the county. Other placers producing were the Eddie, Meadow Creek, Mildred, Nip & Tuck, Ohio, Stockholm, C. B. & Q., Windfall, Blue Bird, and Dakota.

Iron Mountain district.—The principal production was from one property, the Iron Mountain Tunnel, and consisted of zinc-lead sulphide ore and lead sulphide ore.

St. Regis district.—Ore of shipping grade, containing copper and gold, was produced from the St. Lawrence property, and some ore was also produced from the Oro Fino claim.

Saltese district.—The Last Chance claim yielded a small quantity of lead ore containing silver.

MISSOULA COUNTY.

Eight deep mines produced 688 tons of ore. The principal part, 400 tons, yielded gold and silver bullion and 288 tons were shipped directly to the smelters. The total output of ore contained $6,392 in gold, 640 ounces of silver, 35,286 pounds of copper, and 41,394 pounds of lead, valued in all at $20,112, or an average value per ton of $29.23. There were five placers yielding gold and silver bullion, containing $1,242 in gold and 3 ounces of silver.

Coloma district.—Gold ore from the Dandy property, which was operated by a lessee, yielded bullion in its amalgamation mill. The gravel of the Elk Creek placer was sluiced and yielded a small quantity of gold bullion.

Copper Cliff district.—Copper ore containing silver was shipped from the Copper Cliff and Mammoth properties.

Nine Mile district.—Through the operations of four placers an output of $570 in gold was reported.

Ravalli district.—A small quantity of copper ore containing silver was produced from the McDonald property.

Wallace district.—Copper ore, containing silver, was shipped to the smelter from the Hidden Treasure property.

Woodman Creek district.—The Lawyer's Combination property, Thanksgiving, and Bunker Hill claims were producers of silver-bearing copper ore, all of which was shipped directly to the smelter.

PARK COUNTY.

Emigrant Creek district.—There were two placers producing a small quantity of gold.

Natural Bridge district.—Copper ore containing silver was shipped to the smelter from the Drago property.

New World district.—Silver-lead ore, produced from the St. Elmo, Cuba Consolidated, and Yellowstone properties, was shipped to a lead smelter.

Porcupine district.—A small quantity of gold bullion, probably recovered from ore mined in the district, was reported by one operator.

Sheepeater district.—The Jardine mines, operated principally for the production of tungsten ore, were producers of gold bullion, probably recovered in the course of saving scheelite concentrate.

PHILLIPS COUNTY.

Little Rockies district.—Ore from two properties near Zortman, aggregating 219,350 tons, and 4,000 tons of old tailings re-treated, yielded gold and silver bullion by cyanidation. The bullion output of the county and district was second only to that of Lewis and Clark County in 1917 and had a value in gold and silver of $432,853, or of $1.94 a ton. There was a decided decrease in 1917, due in part to labor troubles. The Ruby Gulch Mining Co. has a 600-ton plant, and the value of the gold in the bullion was about eight times the value of the silver. The August Mining Co. operated a 200-ton plant, and the value of the gold in the bullion was approximately half of the value of the silver. The Beaver Creek mine, formerly a good producer, was idle.

POWELL COUNTY.

Mine production in Powell County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
Placers:							
1916	19	....	$22,738	145	....	....	$22,834
1917	17	....	14,194	84	....	....	14,263
Deep mines:							
1916	18	866	10,981	13,585	27,957	86,083	32,736
1917	14	2,145	6,262	8,635	18,859	53,379	23,118
Increase or decrease, 1917	....	+1,279	−13,263	−5,011	−9,098	−32,704	−18,189

Fourteen producers reported in 1917 an output of 2,145 tons of ore, which was 1,279 tons more than was produced by 18 operators in 1916. The total value per ton decreased from $37.80 in 1916 to $10.78 in 1917, and the gold and silver value per ton from $23 to $6.24. Most of the ore, or 1,506 tons, was of milling grade, yielding concentrates containing $1,595 in gold, 2,344 ounces of silver, 11,371 pounds of copper, and 9,951 pounds of lead, valued in all at $7,486, or an average value per ton of $38.39. The ore shipped directly to the smelter aggregated 239 tons, containing $2,945 in gold, 6,227 ounces of silver, 7,488 pounds of copper, and 43,428 pounds of lead, valued in all at $13,859, or an average value per ton of $57.97.

Seventeen placer producers reported $14,194 in gold and 84 ounces of silver in 1917, against an output of $22,738 in gold and 145 ounces of silver in 1916.

Dunkelberg district.—Lead ore, containing a little silver, was shipped to the smelter by the Dunkelberg Mining Co.

Mary Ann district.—The Gray Rock property yielded about a carload of silver-lead ore, containing a little gold. The Marian and Clara May claims were also producers.

Ontario district.—Silver-lead ore from the Black Jack and Monarch properties and copper ore from the Foolhead group constituted the total production of the district in 1917.

Ophir district.—Three deep mines and seven placers produced ore and bullion valued at $7,414. There were 489 tons of ore, containing gold, silver, and copper, which had an average value per ton of $11.90. Some old tailings from the Victor property, re-treated by cyanidation, yielded gold and silver bullion. The Montana Clinton was a producer of copper ore containing silver and gold. Placer operators on seven properties reported the production of $1,586 in gold and 13 ounces of silver.

Pioneer district.—Seven placer operators reported an output of $11,635 in gold and 69 ounces of silver. As in previous years, the Pioneer placer, operated by hydraulicking and sluicing, was the principal producer. There was also some gold produced from the Friday, Oro Fino, and Upper Gold Creek placers.

Snowshoe district.—The Arnold and Wall Street properties each yielded copper ore, containing some silver and gold, which was shipped to the smelter.

Washington Gulch district.—From the operations of placers a small production of gold was reported.

Zozell district.—An important tonnage of lead concentrate, containing gold and silver, resulted from a short mill run on ore from the Emery property. There was also a small production of lead ore from the Bonanza property.

RAVALLI COUNTY.

Curlew district.—Old tailings re-treated in the concentration plant of the Victor Reduction Co. resulted in the shipment of lead and zinc concentrates containing some silver and copper.

Hughes Creek district.—From the operations of placers $831 in gold and 4 ounces of silver were reported.

SANDERS COUNTY.

Eight deep-mine producers reported the output of 1,004 tons of ore, containing $250 in gold, 11,578 ounces of silver, 80,115 pounds of copper, and 133,883 pounds of lead, valued in all at $43,176, or an average value per ton of $43. Compared with 1916, the ore output was 495 tons greater, but the average value per ton was less. Of the output, 201 tons were classified as copper ore, 116 tons as lead ore, and 687 tons as copper-lead ore.

Perma district.—Copper ore from the Exchange property and lead ore containing silver and copper from the Glancus claim were shipped to the smelter.

Revais Creek district.—The Dixon property yielded copper ore containing silver.

Spring Gulch district.—Five producers reported 949 tons of ore, containing $223 in gold, 11,419 ounces of silver, 64,459 pounds of copper, and 132,724 pounds of lead, valued in all at $38,644, or an average value per ton of $40.72. The King & Queen was the principal producer. The milling ore yielded a copper-lead concentrate, and the crude shipping product was copper ore and copper-lead ore. Lead ore of shipping grade containing silver was also produced from the Glen Metals property and the Silver King claim. A lessee shipped a small quantity of copper ore containing silver from the Copper King group.

Trout Creek district.—A small quantity of gold was reported from placers.

SILVER BOW COUNTY.

Mine production in Silver Bow County, Mont., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916............	50	7,209,835	$973,052	14,983,771	349,538,498	9,195,082	224,585,142	$127,547,714
1917............	56	5,681,058	690,801	11,511,600	270,592,901	10,352,453	180,316,415	103,330,806
Increase or decrease, 1917...	....	−1,528,777	−282,251	−3,472,171	−78,945,597	+1,157,371	−44,268,727	−24,216,908

[a] Includes placer production.

Fifty-one mine producers in 1917 reported 5,681,058 tons of ore, practically all of which was produced from the mines in the Butte or Summit Valley district. Most of this ore was produced by a few large operators. The remainder of the producers were lessees operating on various properties. The total average value per ton increased from $17.69 in 1916 to $18.19 in 1917, and the gold and silver value per ton in this ore from $1.50 to $1.79. The gold produced from both deep mines and placers decreased in value from $973,052 in 1916 to $690,801 in 1917, the silver from $9,859,321 to $9,485,558, the copper from $85,986,471 to $73,871,862, and the zinc from $30,094,409 to $18,392,274. Owing to the improved production and better price of lead in 1917, the value of the county output increased from $634,461 to $890,311. The total value of all metals decreased from $127,547,714 in 1916 to $103,330,806 in 1917. The larger part of the ore produced, 4,935,105 tons, was concentrated at milling plants situated at Butte, Anaconda, and Great Falls. The product consisted of lead concentrates, zinc concentrates, copper concentrates, and lead-zinc concentrates, aggregating 1,768,411 tons and containing $585,913 in gold, 9,758,395 ounces of silver, 213,940,098 pounds of copper, 10,347,653 pounds of lead, and 180,290,348 pounds of zinc, valued in all at $86,311,991, or an average value per ton of $48.81. The crude smelting ore amounted to 381,086 tons and contained $95,301 in gold, 1,509,318 ounces of silver, 41,718,253 pounds of copper, 4,800 pounds of lead, and 26,067 pounds of zinc, valued in all at $12,731,134, or an average value per ton of $33.41. A small quantity of gold and silver bullion was produced from 12 tons of ore treated at a gold and silver mill. The ores mined were classified as 4,775,213 tons of copper ore, 633,901 tons of lead-zinc ore, 258,461 tons of zinc ore, and 13,483 tons of dry or siliceous ore. The placer output was $3,658 in gold and 22 ounces of silver, as against $6,262 in gold and 91 ounces of silver in 1916.

Divide Creek district.—Nine deep-mine producers reported 188 tons of ore, containing gold, silver, and copper, valued at $8,520, or an average value per ton of $45.32. The producers of copper ore carrying silver were the Gold King, Combination, Red Rose, Columbia, Copper Bell, Copper King, and Copper Ware.

German Gulch district.—This district, situated 20 miles from Butte, is usually the source of some placer bullion. In 1917 an output of $2,441 in gold and 12 ounces of silver was reported. Some of this production was from the Siberia and Central placers, equipped for hydraulicking and sluicing the gravel.

Highland district.—Placer bullion from the Highland placer of the Butte Water Co., and several smaller lots from various sources credited to the district, contained $1,217 in gold and 10 ounces of silver.

Summit Valley or Butte district.—Since the beginning of activities in 1882 to the end of 1917, Silver Bow County, of which this district covers the largest part, has produced gold, silver, copper, lead, and zinc valued at $1,447,637,563, divided as follows: Gold, $29,390,013; silver, $223,249,431; copper, $1,103,082,221; lead, $2,621,177. In 1905 the production of zinc began, and to the end of 1917 the value amounted to $89,294,721. The values given above are for 1,421,741.84 ounces of gold, 324,603,999 ounces of silver, 7,272,510,606 pounds of copper, 44,164,797 pounds of lead, and 910,955,686 pounds of recoverable zinc. A statement of the figures by years to 1913 may be seen in Mineral Resources for that year.

The principal producers of copper ores in 1917 were the Anaconda, North Butte, Pittsmont, Dutton, Bullwhacker, Balaklava, and Duluth. From the Elm Orlu mine copper ore and a large tonnage of zinc ore were mined; the zinc ore was treated in the Timber Butte mill, where zinc concentrate containing gold, silver, and copper and some lead concentrate were recovered. The Butte & Superior was the largest producer of lead-zinc sulphide ore, containing silver, which yielded, after concentration, lead concentrate as well as zinc concentrate.

The high price of silver has stimulated the revival of old silver properties that had been lying dormant for the last 25 or 30 years. Practically all of the present large operators in the district showed interest in local silver properties. The demand for manganese for the steel industry went hand in hand with the silver development, since most of the old silver mines have good surface showings of manganese ore. The Anaconda Co. is reported to be developing the Nettie, Orphan Girl, and Bonanza claims. The Butte & Superior Co. worked a group of claims in the silver district, the most important of which were the Germania, Tzarina, and Humboldt. The Clark Realty Co. worked the Moulton, Anselmo, and Travona properties. The Butte-Detroit Copper & Zinc Co. mined manganese ore from the Britannia claim and concentrated it at the remodeled Ophir mill, situated in the southwestern part of Butte. The Davis-Daly, besides producing copper from the Colorado ores, extensively developed the Hibernia and Mount Moriah claims, both old silver producers. All this work is said to add to Butte's mining area and extends almost 4 miles southwest of its present productive areas.

In 1917 the Anaconda properties[1] produced 4,193,624.13 tons of ore and 10,011.83 tons of precipitate, or a total of 4,203,635.96 tons, against a total in 1916 of 5,589,157.48 tons. The Washoe reduction works, at Anaconda, treated 4,267,854 tons of ore and other cupriferous material; and the Great Falls plant 813,495.53 tons. Of this quantity, 3,906,901 tons of ore were produced from company mines; 449,513 tons of ore were either purchased from or treated for other companies; and 17,130 tons of precipitates and cleanings came from the old works at Anaconda and Butte. This material, treated at Anaconda and Great Falls copper plants, produced 253,508,332 pounds of fine copper, 9,031,025.78 ounces of silver, and 58,545.604 ounces of gold. The electrolytic copper refinery at Great Falls produced during the year 141,517,768 pounds of cathodes, 132,089,914 pounds of which were melted into shape at Great Falls, and 9,427,854 pounds were shipped to the Raritan copper works for melting. The copper-leaching plant at Anaconda treated during the year 598,370.16 tons of tailings, from which there were produced 10,039,340 pounds of cement copper. The zinc plants at Anaconda and Great Falls treated 326,479.14 tons of ore and other zinciferous material in 1917, of which 257,849.93 tons were produced by mines of the company and 68,629.21 tons of ore were purchased from other companies. At Great Falls 50,624,524 pounds of electrolytic zinc were produced in 1917. The company report contains much of interest, part of which follows:

> During the year much attention was paid to the treatment of complex residues resulting from the zinc-leaching plant. These residues were stock piled until the month of June, when a bag house was put into commission. After continued experimental effort the desired result was obtained, and a reverberatory furnace, smelting zinc residues, was put into regular operation. By means of the method employed satisfactory recovery was made of the gold, silver, copper, and about 20 per cent of the lead contained in the furnace charge. This matte is converted in the usual way; most of the remaining lead is driven as a fume into the bag house, there collected, and then shipped to the lead plant of the International Smelting Co. for further treatment.
>
> The plant recoveries have been very good and have realized the expectations entertained at the time of the reconstruction and improvement of the old and the construction of the new plants. * * *
>
> The zinc-plant construction was completed during the year, and the bag house for collecting lead fume from the reverberatory furnace for smelting zinc-plant residues was completed. Three additional driers were built for the purpose of drying zinc-plant residues preliminary to smelting.
>
> Four additional roasting furnaces were constructed for roasting zinc concentrates. * * * Work was commenced and has progressed satisfactorily on a rod and wire mill. This plant will be capable of rolling into rods 100 tons of copper per day and drawing into wire 80 tons of copper per day. It will roll copper rods and draw copper wire to market specifications. Completion of this mill, which will be approximately coincidental with the issuing of this report, will mark the entry of the company into the metal-manufacturing business.

---

[1] Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

The North Butte properties[1] produced 304,647 wet tons of copper ore and 31 tons of copper precipitate. Of this, there were treated at the Anaconda smelter 296,750 dry tons of ore and 23 dry tons of precipitate. There were 7,202 dry tons of first-class ore, 263,436 tons of second-class ore, and 26,112 tons of third-class ore. All of the ore treated produced 14,493,452 pounds of fine copper, 662,845.79 ounces of silver, and 958.99 ounces of gold. There were also mined 5,770 dry tons of zinc ore, containing 1,222,482 pounds of zinc and 8,800.67 ounces of silver. Dividends paid in 1917 amounted to $1,075,000, the same as in 1916. The company report says:

> Nearly 90 per cent of the entire production of ore for the year was mined prior to June 8, 1917, on which date the mines were thrown out of operation by an unfortunate fire which broke out on the 2,400 level of the Granite Mountain shaft and which burned out the timbering for a length of 1,400 feet and badly caved both the shaft and stations. In repairing the shaft it was decided to use steel and reinforced concrete construction from the 1,600 to the 3,000 levels and also to coat the timbers with cement from the 1,600 level to the surface in order to make the shaft fireproof, this being in line with the policy of the company to make its mines as safe as possible for the workmen.
>
> * * *
>
> It was necessary to employ the Speculator shaft to lower supplies for the repair work at the Granite Mountain shaft.

Nearly all of the copper bullion produced at the Pittsmont smelter at Butte is from the ore of the Pittsmont and Dutton mines. Some ore is purchased from other mines producing ore usually desirable for its fluxing qualities. A 1,200-ton milling plant is attached to the smelter, where lower-grade ores are treated by concentration. The company[2] operating the property mined 181,904 dry tons of first-class and second-class copper ore, against a total output in 1916 of 209,805 tons. Of custom ore, there were treated 30,851 dry tons, which, with ore from the company's mine, yielded 20,013,900 pounds of copper, 581,190 ounces of silver, and 1,825 ounces of gold. The gross value of the metals shipped was $5,317,279.49. According to the company report, the average price of 25.46 cents a pound was paid for copper which cost 17.6727 cents to produce, leaving a profit of 7.7876 cents a pound. The following is from the same report:

> During the first five months of the year (1917) average monthly production of first-class ore was 4,224 tons, and of second-class 14,100 tons. During the succeeding five months corresponding figures were 2,325 tons first class and 6,580 tons second class. In other words, output of first-class ore was reduced by 45 per cent, and second class by 55 per cent. * * *
>
> Owing to an advance in wages and the cost of materials, combined with decreased efficiency of labor, the cost of mining advanced from $5.46 per ton in 1916 to $8.29 per ton in 1917, or 52 per cent. The cost of smelting has for like reasons increased very materially. In the meantime the higher average assay value of all ore mined, namely, 4.31 per cent as against 3.67 per cent for 1916, has tended to reduce the cost of copper per pound, the net result of the effect of these various factors being an increase of 8 mills per pound in the cost of copper delivered in New York.

From the Tuolumne property[3] 29,930 dry tons of ore were shipped containing an average of 1.47 ounces of silver and 0.0072 ounce of gold per ton and of 2.431 per cent of copper, and from the Main Range mine 10,774 dry tons were shipped, averaging 9.42 ounces of silver and 0.0078 ounce of gold to the ton and 1.972 per cent of copper. Production of ore in the Tuolumne mine came principally from the 1,200, 1,400, and 2,600 foot levels, and in the Main Range from the 700-foot level. The company report says:

---

[1] North Butte Mining Co Ann. Rept. for year ending Dec. 31, 1917.

[2] East Butte Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

[3] Toulumne Copper Co. Ann. Rept. for year ending Dec. 31, 1917.

> During the month of April it became necessary to suspend operations due to fire in an adjoining mine which filled the Tuolumne workings with gas and seriously threatened the property. Operations were resumed about June 1, and on June 9 another serious fire in a neighboring property necessitated a second suspension. The labor disturbances during the months of June, July, August, and September interrupted operations to a considerable extent and lowered production.
>
> On account of the constantly increasing cost of production it was deemed advisable to suspend operations at the Tuolumne mine on January 1, 1918.

In 1917 the Butte & Superior mine[1] produced 461,953 tons of milling ore, this being a little less than 75 per cent of that milled in 1916. The mill recoveries averaged 91.13 per cent of the zinc content. Mining costs were 65 cents greater, or $5.15 a ton in 1917, and the direct cost of milling the ore was $2.52 a ton. Dividends paid in 1917 amounted to $1,567,057, and capital distribution was $362,747, which, added to the total paid by the company in the past, makes $16,940,257.88, or at the rate of $59.65 per share. The company report says:

> On account of the labor troubles which developed in June, and the resultant discontinuance for a time and curtailment thereafter of production from the property, it was considered unnecessary to hoist any ore through the new shafts, although the two new electric hoists were installed and in satisfactory operating condition about the middle of the year.
>
> The No. 3, or new ore shaft, was sunk to a depth of 119 feet below the 1,900-foot level and will be continued to a point 50 feet below the 2,050-foot level, at which depth it will be discontinued for the present and a station cut at the 1,900-foot level. * * *
>
> On practically all of the levels of the mine there was shown by development work a very satisfactory extension of existing ore bodies. Above the 1,200-foot level there was added to ore reserves a total of 111,100 tons, leaving almost as much ore in sight above this level as was included in the records of a year ago and extending the future life of these levels accordingly. A considerable portion of this ore of rather high grade was developed in the Jersey Blue vein and a substantial tonnage of medium or low-grade ore in the Overman claim, where between the 1,000 and 1,300 foot levels there was mined a large tonnage of ore of rather low grade but commercially profitable under conditions existing, especially during the early part of the year. * * * On the 1,400-foot level good ore has been disclosed for a distance of approximately 200 feet in the Deadwood vein, and stoping operations have been commenced. Developments to date on the 1,900-foot level amount to only about 200 feet in length on the vein, this disclosing ore of a fair grade, such as was indicated by the workings immediately above on the 1,800-foot level. * * *
>
> Estimate of ore reserves as of December 31 shows 1,059,200 tons, averaging 17.6 per cent zinc and containing 5.9 ounces of silver per ton. * * *
>
> During the early part of the year approximately 6,140 tons of concentrates were shipped to the plants of the American Zinc, Lead & Smelting Co., and 2,658 tons to the United States Smelting Co., practically all of the balance during that period going to the American Metal Co. under regular contract. Subsequent to February all of the production of concentrates, with the exception of a few thousand tons disposed of by sale to other smelters, was shipped to the American Metal Co.
>
> All residues were disposed of, about 6,900 tons remaining on hand at the plants of the American Zinc, Lead & Smelting Co. being sold for delivery during the first five months of the year 1918. Unsold spelter to the amount of 3,081 tons remained on hand at the plants of the American Zinc, Lead & Smelting Co. and the United States Smelting Co.

---

[1] Butte & Superior Mining Co. Sixth Ann. Rept. for year ending Dec. 31, 1917.

Crude ore treated and concentrates produced at Butte-Superior mill in 1917.

Ore and product.	Quantity (tons).	Gold.		Silver.	
		Total content.	Average per ton.	Total content.	Average per ton.
		Ounces.	*Per cent.*	*Ounces.*	*Per cent.*
Crude ore, milled	461,953	4,196.128	0.00908	2,679,462.39	5.8003
Zinc concentrate	[a] 138,661	3,842.391	.0277	2,472,985.40	17.8348
Lead concentrate	2,543	75,921	.0296	54,316.82	21.3620

Ore and product.	Copper.		Lead.		Zinc.	
	Total content.	Average per ton.	Total content.	Average per ton.	Total content.	Average per ton.
	Pounds.	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
Crude ore, milled	1,586,302	0.1717	10,082,584	1.0913	142,920,807	15.4692
Zinc concentrate	1,304,739	.4705	9,289,683	3.3498	131,337,299	47.3636
Lead concentrate	14,831	.2917	1,808,368	35.5600	699,436	13.7540

[a] Includes concentrates from tailing re-treated.

During 1917 the Emma mine[1] produced 42,248.46 tons of zinc ore, which was treated under contract at the zinc concentrator of the Washoe plant near Anaconda, and the zinc concentrate was shipped and treated by the electrolytic zinc plant at Great Falls. Advantage was taken of the prevailing high prices paid for manganese ore, and toward the end of 1917 test shipments of rhodochrosite, or carbonate of manganese, which has been developed in comparatively large bodies in this mine, were made to eastern steel plants. The results were satisfactory, and this ore, heretofore considered valueless, promises to become the source of income during 1918.

---

[1] Under lease from the Butte Copper & Zinc Co.; mentioned in Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1917, p. 7.

QUICKSILVER.

By F. L. Ransome.

STATISTICAL SUMMARY.

Quicksilver produced in the United States in 1917.

State.	Ore treated (short tons).	Percentage tenor won.	Flasks of 75 pounds.	Value.
California	235,786	0.38	23,938	$2,521,151
Texas	28,242	1.42	10,791	1,136,508
Nevada	3,639	1.02	997	105,004
Oregon	12,732	[a].11	388	40,864
Arizona	79	1.90	40	4,213
Idaho	6	3.12	5	526
	280,484	.48	36,159	3,808,266

[a] Abnormally low, owing to accumulation of unworked soot.

Average price per flask:		
San Francisco		$105.32
New York		$106.30
London		£22 5s. 3d.
Total number of mines producing		51
Total increase of production in 1917 over 1916	flasks	6,227
Total exports from United States	pounds	808,336
Total imports into United States	do	390,494

INTRODUCTION.

That there was unusual activity in quicksilver mining in the United States in 1917 is shown by the fact that the production rose to 36,159 flasks, a quantity that has not been reached since 1883. The increased output, however, was obtained almost wholly from mines that had been productive in preceding years and not from newly discovered deposits. The high price of quicksilver has not led to as much prospecting, either of new territory or in well-known quicksilver districts, as might have been expected, and at comparatively few places have energetic efforts been made to reopen old mines that were abandoned when prices were from one-third to one-half of those that have prevailed during the past three years. Known resources of ore have been drawn upon heavily in order to take advantage of a good market, but less attention has been given to mine development and to the search for new ore bodies than is requisite if production is to increase or even if it is to be maintained at its present level. The war has not only increased greatly the demands for quicksilver to be used in fulminate, drugs, and marine paint but it has brought about some new and important applications that can not at present be described. Although it is a difficult matter to estimate with accuracy the quantities of quicksilver that are consumed annually in the manufacturing industries of the country, such estimates as have been made indicate that the output for 1917, and so far as can be foreseen the output for 1918, will have to be considerably surpassed if all demands for the metal, including those of the Government, are to be met from domestic sources in 1919. There is every reason to expect that prices will continue high during that year and that some new uses discovered for quicksilver will persist and even increase after peace is declared. The metal is not likely to fall to its prewar price for some years, if at all, and it would seem that both patriotism and self-interest should induce those owning idle mines in which there may still remain bodies of ore, or from which additional exploration might be carried out with no more than the usual chances inseparable from quicksilver mining, to use every effort to place them again in the productive class. The apparent success of the rotary furnace in California and the substitution of wooden for brick condensers promise to be important steps toward lessening the initial cost of equipping a quicksilver mine and in diminishing the amount of capital hitherto locked up in immobile, unsalable brick structures capable of absorbing and retaining thousands of dollars' worth of quicksilver.

It will probably be noted that the present report is longer than its immediate predecessors, owing chiefly to the inclusion of a general review of the more important quicksilver deposits of the world, a section on the mineralogy of quicksilver ores, and an extensive bibliography. It is not intended to repeat these features annually, but the present interest in quicksilver as one of the necessities of modern warfare, not only as a potent means of destruction but also as an essential ingredient of preservative and medicinal compounds, renders this a particularly appropriate time to put into practice the Survey's policy of presenting an occasional summary of more general information concerning the metal than would be comprised in a purely statistical investigation. It is hoped that, with prompt returns from the producers, the briefer reports planned for the next few years may each appear within a very few months after the end of the year to which it pertains.

To Mr. H. D. McCaskey, author of the Survey's statistical reports on quicksilver from 1907 to 1916, and still in charge of the Division of Mineral Resources, I am deeply indebted not only for material turned over to me for use in this report but for friendly advice and suggestions drawn from his long familiarity with the quicksilver industry that have been most helpful to one taking up the statistical phase of the subject for the first time. Special acknowledgments are due also to the quicksilver-mine operators, with most of whom I have been so fortunate as to come into enjoyable personal contact, for their courteous considerations and for the public spirit and patience with which they have responded to inquiries. As a class their patriotism and their frankness in supplying information are unquestionable, and this attitude has been an inspiring feature of the work upon which the present report is based. Finally, attention may appropriately be called to the very careful and painstaking work of Miss I. P. Evans in the preparation of the bibliography appended to the report, which, it is hoped, will be of assistance to those desiring to turn to original sources of information on quicksilver in North America.

PRODUCTION.

DOMESTIC.

Including some small prospects that yielded only a flask or two from development work, there were 51 productive quicksilver mines in the United States in 1917, against 66 in 1916 and 39 in 1915. This number includes four sources of metal entirely from old dumps and at least two important mines at which dumps and ground under old reduction works contributed a large part of the total output. Of the productive mines, 34 were in California, 8 in Nevada, 4 in Texas, 2 in Oregon, 2 in Arizona, and 1 in Idaho.

According to confidential returns to the Geological Survey from individual mine operators, the output of quicksilver in the United States in 1917 was 36,159 flasks of 75 pounds each, against 29,932 flasks in 1916 and 21,033 flasks in 1915. This production was the greatest in quantity since 1883, when the output was 46,725 flasks. The notable increase of production during the last three years, while it shows that the industry has been capable of reaction under the stimulus of prevailing prices, can not in itself be accepted as an earnest of continued improvement at a similar rate. The prices obtainable for quicksilver have led to considerable activity in prospecting and to development on a small scale, but only in rare instances have they induced large expenditure in development or equipment with a view to long-continued production. There

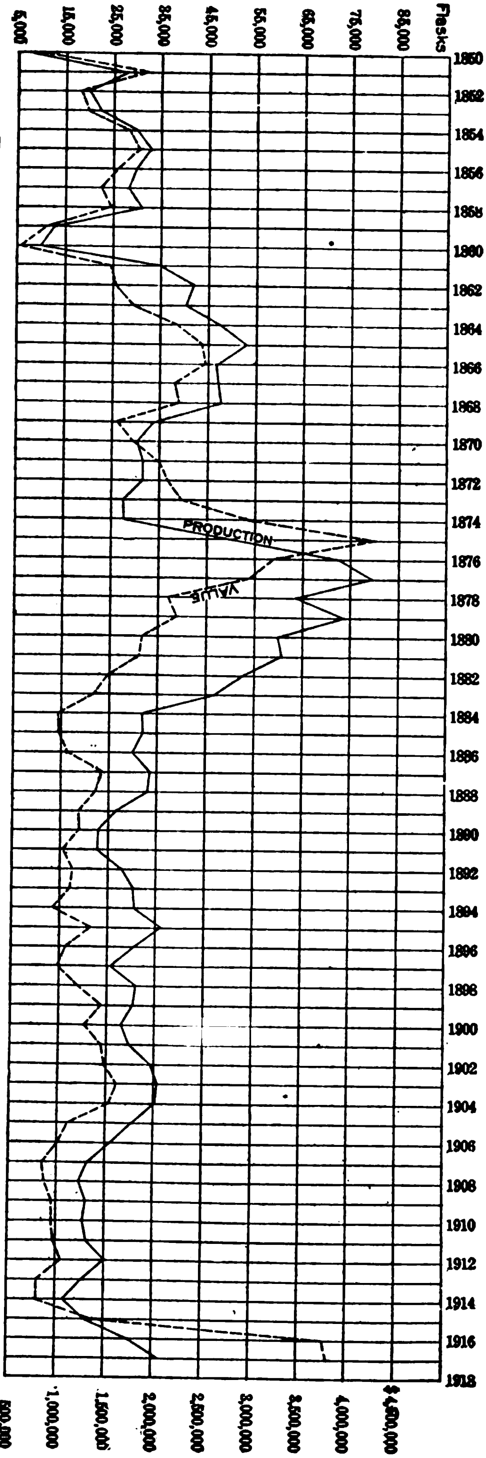


FIGURE 3.—Diagram showing quantity and value of quicksilver produced in the United States from 1850 to 1917, inclusive.

has been a tendency to exhaust known reserves and enlarge old stopes and to neglect the systematic search for new ore bodies, which is so necessary if a mine is to maintain its productivity. In other words, the effort during the last two or three years has had much of the character of a spurt that can not be indefinitely maintained. The failure, except in one or two instances, of high prices to revive extensive operations at mines once productive but long idle has been distinctly disappointing to those interested in the growth of the quicksilver industry. The known facts indicate that the output for 1918 is not likely to reach 36,000 flasks.

At the average price for the year, $105.32 a flask, based on quotations for domestic quicksilver in San Francisco, published weekly in the Mining and Scientific Press, the value of the output in 1917 was $3,808,266, a sum exceeded only in the year 1875, when the value of the output was $4,228,538. The producers of 33,529 out of the total 36,159 flasks stated on their statistical returns the prices received for their product. These averaged $104.23 a flask, or $1.09 less than the average quotation in San Francisco.

Compared with 1916, the quicksilver yield for 1917 shows an increase of 21 per cent in quantity but of only about 1 per cent in value. The production of California increased 14 per cent in quantity but decreased 5 per cent in value in 1917 as compared with 1916.

Quicksilver produced in the United States, 1913–1917, in flasks of 75 pounds.

State.	1913		1914		1915		1916		1917	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity	Value.
Arizona	2,977	$119,765	3,156	$154,801	4,423	$379,493	5	$629	40	$4,213
Oregon [a]							[b] 378	47,587	388	40,864
Texas							6,306	793,862	10,791	1,136,508
California	15,591	627,228	11,303	554,414	14,283	1,225,481	21,045	2,649,355	23,938	2,521,151
Nevada	1,645	66,178	2,089	102,465	2,327	199,657	2,198	276,706	997	105,004
Idaho	......	....	......	....	......	....	......	....	5	526
	20,213	813,171	16,548	811,680	21,033	1,804,631	29,932	3,768,139	36,159	3,808,266

[a] Oregon had no output in 1913 and 1914.

[b] Includes 75 flasks from Washington.

The following table gives the quantity, average price, and value of the quicksilver produced annually in the United States from the year 1850. Up to 1882 this table is identical with that on page 406, which shows the production of California:.

Quicksilver produced in the United States, 1850–1917.

[In flasks of 76.5 pounds to June, 1904; subsequently in flasks of 75 pounds.]

Year.	Flasks.	Price per flask.	Value.	Year.	Flasks.	Price per flask.	Value.
1850	7,723	$99.45	$768,052	1885	32,073	$30.75	$986,245
1851	27,779	66.93	1,859,248	1886	29,981	35.50	1,064,325
1852	20,000	58.33	1,166,600	1887	33,825	42.375	1,433,334
1853	22,284	55.45	1,235,648	1888	33,250	42.50	1,370,625
1854	30,004	55.45	1,663,722	1889	26,484	45.00	1,191,780
1855	33,000	53.55	1,767,150	1890	22,926	52.50	1,203,615
1856	30,000	51.65	1,549,500	1891	22,904	45.25	1,036,406
1857	28,204	48.73	1,374,381	1892	27,993	40.71	1,139,595
1858	31,000	47.83	1,482,730	1893	30,164	36.75	1,108,527
1859	13,000	63.13	820,690	1894	30,416	30.70	933,771
1860	10,000	53.55	535,500	1895	36,067	37.04	1,335,922
1861	35,000	42.05	1,471,750	1896	30,765	34.96	1,075.544
1862	42,000	36.35	1,526,700	1897	26,691	37.28	995,040
1863	40,531	42.08	1,705,544	1898	31,092	38.23	1,188,647
1864	47,489	45.90	2,179,745	1899	30,454	47.70	1,452,656
1865	53,000	45.90	2,432,700	1900	28,317	44.94	1,272,566
1866	46,550	53.13	2,473,202	1901	29,727	48.46	1,440,570
1867	47,000	45.90	2,157,300	1902	34,291	43.20	1,481,371
1868	47,728	45.90	2,190,715	1903	35,634	45.29	1,613,864
1869	33,811	45.90	1,551,925	1904	35,315	43.50	1,536,203
1870	30,077	57.38	1,725,818	1905	30,534	36.22	1,105,941
1871	31,686	63.10	1,999,387	1906	26,083	39.50	1,030,279
1872	31,621	65.93	2,084,773	1907	21,554	39.60	853,538
1873	27,642	80.33	2,220,482	1908	19,752	44.17	872,446
1874	27,756	105.18	2,919,376	1909	21,075	45.45	957,859
1875	50,250	84.15	4,228,538	1910	20,601	46.51	958,153
1876	72,716	44.00	3,199,504	1911	21,256	46.01	977,989
1877	79,395	37.30	2,961,434	1912	25,064	42.05	1,053,941
1878	63,880	32.90	2,101,652	1913	20,213	40.23	813,171
1879	73,684	29.85	2,199,467	1914	16,548	49.05	811,680
1880	59,926	31.00	1,857,706	1915	21,033	85.80	1,804,631
1881	60,851	29.83	1,815,185	1916	29,932	125.89	3,768,139
1882	52,732	28.23	1,488,624	1917	36,159	105.32	3,808,266
1883	46,725	28.75	1,343,344				
1884	31,913	30.50	973,347		2,305,130	....	108,708,078

The quantity and value of the quicksilver produced annually in the United States are also shown graphically in figure 3.

WORLD'S PRODUCTION.

In the following table are given the best figures available for the world's production of quicksilver in recent years. The foreign figures, generally published in metric tons, are calculated to flasks of 75 pounds net by multiplying by the factor 29.395. As far as possible the figures are taken from official statistical publications of the respective countries. Where no trustworthy data are obtainable the output is estimated on such miscellaneous information as could be collected. This expedient unfortunately has been necessary in the case of Austria and Hungary, for which no statistics have been obtainable since the outbreak of the war. The estimate of production for "Mexico and other countries" is admittedly based upon very meager data. The figures given for the years 1908 to 1915 in earlier reports have been thoroughly revised and Government sources substituted, where possible, for unofficial publications previously cited.

World's production of quicksilver, 1908–1917, in flasks of 75 pounds.

[1 metric ton=29.395 flasks.]

Country.	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
United States	19,752	21,075	20,601	21,256	25,064	20,213	16,548	21,033	29,932	36,159
Austria	[a] 16,814	[a] 17,196	[a] 17,725	[a] 20,694	[a] 22,428	[a] 24,104	[b] 25,000	[b] 25,000	[b] 25,000	[b] 25,000
Hungary	[c] 2,289	[c] 2,098	[c] 2,641	[c] 2,339	[c] 2,494	[c] 2,606	[b] 2,500	[c] 2,500	[b] 2,500	[b] 2,500
Italy	[d] 20,106	[d] 22,668	[d] 26,264	[d] 28,072	[d] 29,406	[d] 29,513	[d] 31,541	[d] 28,954	[e] 32,129	[f] 29,300
Russia	[g] 1,389	[h] 206	[h] 118	....	....	....	....	[i] 800	[i] 1,100	[b] 500
Spain	[j] 31,382	[j] 40,933	[j] 32,892	[j] 43,912	[j] 36,921	[j] 36,619	[j] 28,000	[j] 35,925	[j] 23,369	[j] 25,133
Mexico and other countries	[b] 5,880	[b] 4,500	[b] 4,500	[b] 4,500	[b] 4,500	[b] 4,000	[b] 4,000	[b] 4,000	[b] 4,000	[b] 4,000
	97,612	108,676	104,741	120,773	120,813	117,055	107,589	118,212	118,030	122,592

[a] Statistik des Bergbaues in Österreich, Wien.

[b] Statistics not available. Estimate only.

[c] Ungar. statist. Jahrb., Budapest.

[d] Riv. servizio min., Roma.

[e] Min. Jour., London.

[f] Eng. and Min. Jour., Feb. 16, 1918 ("nearly 1,000 tonnes").

[g] Statistics of the mineral industry of Russia, Petrograd.

[h] Metallgesellschaft, Frankfurt-am-Main.

[i] Statistics not available. Estimate based on oral information from Russian Special Commission to United States in 1917.

[j] Estadística minera de España, Madrid.

QUANTITY AND TENOR OF ORE TREATED.

According to reports from producers there was mined in 1917 about 289,400 short tons of ore, inclusive, however, of considerable material, not separately reported by the mine operators, obtained from dumps and from the wrecking of old furnaces and condensers. There was treated in furnaces 264,691 short tons of ore (including some concentrates), which yielded 32,956 flasks of quicksilver. This is at the rate of 0.46 per cent, or 9.2 pounds of quicksilver to the ton of ore. There was treated in retorts 7,107 tons of ore, which yielded 2,320 flasks. This is at the rate of 1.22 per cent, or 24.4 pounds to the ton. In addition there was retorted about 900 tons of concentrates from old dumps, which yielded 548 flasks. The greater part of this material came from the extensive dumps at Sulphur Bank, Cal. There was also passed through a washer 7,786 tons of earth from the sites of old furnaces, which yielded 335 flasks of quicksilver without further metallurgical treatment.

Quicksilver ore treated and metal won in the United States, 1914–1917.

State.	1914			1915			1916			1917		
	Ore treated (short tons).	Metal won (pounds per ton).	Percentage tenor won.	Ore treated (short tons).	Metal won (pounds per ton).	Percentage tenor won.	Ore treated (short tons).	Metal won (pounds per ton).	Percentage tenor won.	Ore treated (short tons).	Metal won (pounds per ton).	Percentage tenor won.
Arizona	7,334	32.3	1.62	7,321	45.3	2.27	2	......	......	79	38.0	1.90
Oregon [a]							[b] 5,802	4.8	0.24	12,732	[c] 2.3	[c] .11
Texas							25,945	18.2	.91	28,242	28.4	1.42
California	101,553	8.3	.42	129,521	8.3	.41	205,072	7.6	.38	235,786	7.6	.38
Nevada	14,111	11.1	.56	21,975	7.9	.40	12,911	12.6	.63	3,639	20.4	1.02
Idaho	....	......	......	....	......	......	....	......	......	6	62.4	3.12
	122,998	10.1	.50	158,817	9.9	.50	249,732	9.0	.45	280,484	9.6	.48

[a] Oregon had no output in 1914.

[b] Includes 47 tons from Washington.

[c] These figures abnormally low, owing to accumulation of unworked soot.

The table below shows the relative importance of furnaces and retorts in the production of domestic quicksilver. The furnaces are preponderantly fine-ore inclined-tile furnaces of the Hüttner-Scott type, but include some coarse-ore shaft furnaces of simple construction and a few exceptional models. The retorts are chiefly of the cylindrical pipe form, usually arranged in "banks" or "benches" of 12 retorts, but include also a number of the D pattern and a few unusual varieties.

Quicksilver ore treated in furnaces and in retorts in 1917.

State.	Ore treated (short tons).		Quicksilver won (flasks).		Percentage tenor won.	
	Furnaces.	Retorts.	Furnaces.	Retorts.	Furnaces.	Retorts.
California [a]	223,069	[b] 4,931	21,780	1,823	0.37	1.44
Texas	26,802	1,440	10,530	261	1.47	.68
Other States [c]	14,820	1,641	646	784	.16	1.79
	264,691	8,012	32,956	2,868	.46	1.34

[a] This table does not include 7,786 tons of material taken from under old reduction works, which yielded 335 flasks of quicksilver by washing.

[b] Includes the Sulphur Bank product as concentrates, not as the crude dump material sent through the mill.

[c] Includes Arizona, Nevada, Oregon, and Idaho.

METHODS OF TREATMENT.

The metallurgy of quicksilver is now being studied for the United States Bureau of Mines by Dr. L. H. Duschak, superintendent of the Bureau's station at Berkeley, and will probably be discussed also in a bulletin on quicksilver in California prepared for the California State Mining Bureau by Walter W. Bradley and now in press. It is not the purpose of the present report to treat extensively of the metallurgical side of the industry but merely to give to the reader a brief outline of the ways in which quicksilver is being obtained from its ores. Those who wish to pursue the subject further may profitably consult the full bibliography prepared by Miss Evans and appended to this report.

The ores of quicksilver, unlike those of most metals that are won by smelting, are without exception in this country treated at the mines, and the liquid metal is shipped as a finished commercial product. A moderate heat, about 360° C., is sufficient to vaporize and decompose cinnabar, and metallic quicksilver is readily obtained by condensation. In outline the process is exceedingly simple, but in practice it is by no means easy so to control the operation as to obtain practically all of the metal from the ore with the minimum expenditure of labor and fuel.

In general, two classes of reducing plants may be distinguished, namely, furnaces and retorts. In the furnaces, with the exception of the Fitzgerald furnace and the Livingston retort furnace, which are little used, the ore is exposed to the direct action of the flame and the volatile products of combustion, with more or less dust, as well as the mercury vapor, are drawn into the condensing chambers. In retorts, on the other hand, the ore is heated in a closed vessel, out of contact with the flame, and only those volatile constituents that are driven off from the charge pass into the condensers. Furnaces are comparatively expensive but have greater capacity than retorts, cost much less to operate per ton of ore, and, for ores of medium and low grade, are more efficient. Retorts, on the other hand, are comparatively cheap and can be successfully employed in treating small bodies of rich ore, although their use is attended with the ever-present danger of salivation or mercurial poisoning. The relative importance of the two classes of reduction plants may be seen from the table on page 373.

The standard furnace in the United States is the Hüttner-Scott, or, as it is commonly called, the Scott furnace. This is a masonry structure of rectangular shaft form and requires special skill in its construction. The ore is fed at the top and falls over a series of alternating or "staggered" fire-brick shelves inclined at 45°. The rate of passage through the furnace is controlled by drawing off portions of the spent charges at regular intervals from the bottom of the shaft, and the burning is continuous. The flames pass back and forth through the flues formed by the spaces that the ore does not fill under the sloping shelves. The shelves are arranged in one to five vertical compartments, according to the size of the furnace. The fuel is wood or oil and is burned in one or more fire boxes, not mixed with the ore.

At the Oceanic mine in California, where Scott furnaces are successfully used on ore yielding 3.7 pounds of quicksilver to the ton of ore, the consumption of wood is 0.031 cord to the ton. Scott furnaces usually range in capacity from 10 to 80 tons of ore for each 24 hours and, when skillfully handled, are very efficient. They are, however, expensive to build, difficult to repair, rather slow in action, absorb considerable quicksilver, and can not be moved.

These disadvantages, which apply in some degree also to other masonry furnaces, have led to attempts to utilize the tubular, rotating cement kiln as a quicksilver furnace. Recently Mr. H. W. Gould, general superintendent of the New Idria and Sulphur Bank mines in California, undeterred by the unsuccessful attempts of others to adapt these furnaces to the metallurgy of quicksilver, has installed them at Idria and Sulphur Bank. He reports as follows concerning their operation:

> These furnaces as applied to quicksilver reduction are an adaptation of the rotary furnace in general use for cement burning, with such modifications in design and operation as are necessary and with provision made for taking the fumes from the furnace to a suitable condensing system.
>
> The first furnace installed was a tube, 48 inches in diameter by 50 feet in length, made of ⅜-inch boiler plate, with a lining 4 inches thick of segmental fire brick. It is mounted on two sets of riding rings and trunnions, on which it revolves, and is driven through gears at a speed of from one-half to four revolutions per minute. The ore is fed from the ore bin by a crawl feeder to a screw conveyer, which carries the ore through a brick dust chamber and drops it on the floor of the furnace. As the tube has an inclination of one-half inch to the foot, the ore moves down from the feed end to the discharge end as the tube revolves.
>
> The furnaces are fired by oil sprayed directly into the tube, through the discharge end, or by wood burned in a fire box leading into the tube. Rub joints at each end of the tube prevent fume leakage. The fumes are led from the dust chamber through vitrified earthenware pipes 12 to 24 inches in diameter, into which cold air and some water are introduced as a spray under high pressure. From the pipes the vapors and fumes are conducted into large cylindrical wooden tanks from which the uncondensed fumes pass out to a stack.

Furnaces have been made in the following sizes:

One 36-inch by 38-foot; capacity 10 to 30 tons.
Three 48-inch by 50 or 56 foot; capacity 40 to 100 tons.
Four 60-inch by 56-foot; capacity 75 to 150 tons.

Some of these are now in operation, and all will be within the next 60 days. The capacity of the furnace depends upon the character of the ore and the fuel used. Oil fuel is preferable to wood. The larger furnaces are economically more efficient than the smaller ones.

The first furnace erected was a 48-inch by 50-foot tube at Idria. It was placed in use about March 1, 1918, and has been in continuous successful operation since. A few modifications have been made in subsequent installations but no radical changes.

The rotary furnace appears to have the following advantages: Low cost of installation; low fuel consumption per ton of ore roasted; great flexibility in operation, as it can be fired up in a short time and closed down instantly; better metallurgical practice, as it almost eliminates absorption losses; decreased labor costs, as both the charging and drawing are automatic; availability for burning very fine ore or dust if necessary; last, but not least, absence of the possibility of mercurial poisoning or salivation of workmen.[1]

At the Goldbanks mine in Nevada and at the El Senador mine of the New Almaden Co. in California furnaces of the Herreshoff type, with revolving rabbles, have been used for quicksilver ore. Their efficiency for this purpose, however, does not appear to have been fully established.

The condensing systems used with quicksilver furnaces vary greatly, and at no two mines are they identical. The standard, until recently, was a series of rectangular brick chambers, with small holes and a trough along one side at the base to conduct the quicksilver to a collecting reservoir. Present practice in California tends to rectangular chambers or cylindrical tanks of redwood lumber. These cost less than brickwork, have better radiation, are easier to clean, and absorb less mercury. At some mines condensers of vitrified earthenware pipe are successfully employed.

As a rule a considerable part of the quicksilver retained in furnace condensers is in the form known as "soot," a dark-gray to black material containing metallic mercury mixed with exceedingly fine solid particles of various materials including ore dust and unconsumed hydrocarbons. The proportion of soot to free quicksilver varies widely with the character of the ore and the operation of the furnace. In one or two mines practically all of the product is in the undesirable form of soot. A large part of the quicksilver is extracted from the soot by kneading the mass with hoes on iron plates or with a machine for the purpose, when the metal runs out. The residual mass is then recharged into the furnace, or, more commonly, treated in retorts.

As the Johnson-McKay type of retort is so largely used in development of prospects, the following data from a letter to the Survey from the Joshua Hendy Iron Works, San Francisco, makers of this retort, are given as of general interest to the industry:

The Johnson & McKay quicksilver furnace consists of a series of retort pipes set up in brickwork, complete with covers, condenser pipes, etc. The retort pipes are furnished either 10-inch or 12-inch diameter, the larger size being preferable. The usual furnace consists of a battery of twelve 12-inch pipes, but a less number of pipes may be installed, if desired.

With a 12-pipe retort, where the duration of the roasting period for each charge of ore would take 12 hours, the operation of this furnace is continuous, in that one pipe is unloaded and recharged with ore every hour. When the pipes are sufficiently heated they are successively charged with ore at hourly intervals, so that at the end of 12 hours the charge in the first pipe will have roasted for that length of time, and the last pipe will have been charged. The first pipe is then ready for unloading and recharging. At the end of the next hour the second pipe is unloaded and recharged, and this operation is continued indefinitely. This cycle of operation is based, however, on a 12-hour roasting period for each charge of ore; but that the length of the roasting period may vary is obvious, this being dependent on the character of the ore, the intensity of heat maintained in the furnace, the experience of the attendant, etc.

---

[1] Letter dated Aug. 22, 1918.

It will be understood also that the capacity of these furnaces varies. We will say, however, that the capacity of a twelve 12-inch pipe retort is usually rated at 5 tons per 24 hours, but some users of this same size of furnace have reported a daily capacity of 7 tons. Using wood for fuel, the consumption is about 1¼ to 1½ cords per day.

Concentration by the ordinary wet gravity methods has not proved generally successful with quicksilver ores in competition with the low cost and high efficiency of furnace reduction. The only mill in operation on quicksilver ore throughout 1917 was at New Idria, Cal., and this was continued in use only because the ratio of fine ore to coarse ore exceeded the limit set by the furnace capacity of the plant. In the later part of the year there was also in operation the 400-ton mill at Sulphur Bank, treating dump material, but this will probably be abandoned also when adequate furnaces have been constructed. There were also running for part of the year the 100-ton mill at the January (Harrison) mine and a small mill, since abandoned, at the Bella Union mine. At the Black Butte mine, Oreg., an experimental flotation mill was operated for part of the year and proved so successful that a 40-ton mill was equipped for flotation early in 1918.

COSTS.

The question, "How much does it cost to produce a flask of quicksilver?" has been frequently asked of late and is not easily answered. So many factors enter into the problem that it is difficult, as regards relative efficiency, to arrive at a satisfactory basis of comparison between mine and mine or between one region and another. Under otherwise identical conditions it costs very little more to produce 2 flasks from 2 per cent ore than to produce 1 flask from 1 per cent ore, as in each case the same quantity of ore is mined and treated. Practically the only increased cost in connection with the higher-grade ore is the small one involved in bottling, transporting, and selling the larger output. Conditions, however, are never identical. The higher-grade ore may be less favorably situated, may require more expensive mining, or may demand more careful sorting than the lower-grade ore, and these disadvantages may offset the initial advantage of higher tenor. In many mines the tenor of the ore as mined is, within certain limits, under the control of the operator, who faces the problem of determining the particular relation between quantity of ore mined, tenor, labor, equipment, and capital that will yield him the most profit. With ores which yielded an average of only 0.38 per cent of quicksilver, the average cost, inclusive of operating expenses, development work, and ordinary amortization charges, of producing and selling a flask of the metal in California in 1917 was from $65 to $70. The cost in Texas is undoubtedly higher on ore of the same grade, but Texas ores in 1917 showed the relatively high average tenor of 1.43 per cent.

An attempt has been made to determine the approximate number of flasks produced annually per man employed and the quantity of quicksilver corresponding to each man-day of labor in the two principal quicksilver States. Reliable and complete figures on the average number of men employed and the total number of man-days of work in each State are not available, however, and recourse must be had in part to estimates. Consequently, the figures that follow can be regarded only as rough approximations.

It is estimated that in California in 1917 about 950 men were employed in the mining and metallurgy of quicksilver and that these worked 310,500 man-days. There was treated in the same year in that State 235,786 short tons of ore, which yielded 23,938 flasks of quicksilver, or 0.38 per cent. This corresponds to 248.1 tons handled and 25.1 flasks produced per man annually, or 0.75 ton and 0.077 flask per man-day.

In comparing 8 of the most productive and representative mines at which furnaces were used in California, it is found that in 1917 they treated 203,449 tons of ore, from which were obtained 18,581 flasks of quicksilver. The proportion of quicksilver won from the ore in these eight mines ranged from 0.17 to 1.08 per cent, and the

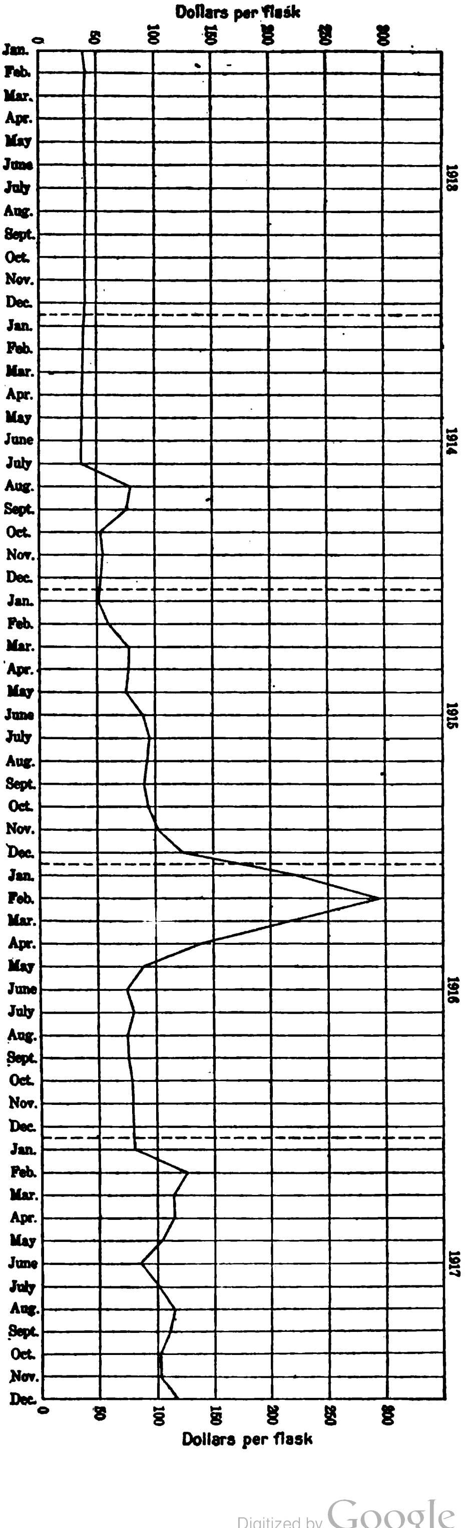


FIGURE 4.—Diagram showing variations of monthly average market quotations for domestic quicksilver at San Francisco from 1913 to 1917, inclusive.

average was 0.336 per cent. As nearly as can be determined these mines employed an average of 715 men, who worked, it is estimated, 233,689 man-days. The quantity of treated ore handled per man during the year ranged from 119.1 to 624.4 short tons at the different mines and averaged for all of them 322.8 tons. The quantity handled per man-day ranged from 0.365 to 1.905 tons, and averaged 0.987 ton. The number of flasks obtained per man for the year ranged from 16.3 to 34.4 and averaged 26. The number of flasks per man-day ranged from 0.050 to 0.105 and averaged 0.079.

A comparison of three mines at which furnace reduction was practiced in Texas in 1917 shows that these mines treated 26,802 tons of ore, from which were won 10,530 flasks of quicksilver. The proportion of metal obtained ranged from 0.55 to 3.88 per cent, and the average was 1.47 per cent. The three mines employed an average of 253 men, who worked 84,795 man-days. The quantity of treated ore handled per man during the year ranged from 73 to 140.2 tons and averaged 105.9 tons. The quantity handled per man-day ranged from 0.233 to 0.384 ton and averaged 0.316 ton. The number of flasks obtained per man for the year ranged from 12.3 to 84.1 and averaged 41.6. The number of flasks per man-day ranged from 0.039 to 0.271 and averaged 0.124.

The data just presented for California and Texas are summarized in the following table, which, owing to the uncertainty attaching to the labor figures, especially to those for man-days, is presented merely as a rough approximation to the truth.

Relations of quicksilver production to labor in California and Texas.

State.	Ore treated (short tons).	Quicksilver produced (flasks).	Tenor won.	Average number of men employed.	Man-days of work.	Quantity of ore treated per man (short tons).	Quantity of ore treated per man-days (short tons).	Quicksilver obtained per man annually (flasks).	Quicksilver obtained per man-day (flasks).
California:									
All mines	235,786	23,938	0.38	950	310,500	248.1	0.75	25.1	0.077
Eight leading mines	203,449	18,581	.34	715	233,689	322.8	.99	26.0	.079
Texas:									
Three mines	26,802	10,530	1.47	253	84,795	105.9	.32	41.6	.124

Foreign costs are particularly difficult to ascertain under present conditions. Prior to the war the cost of producing a flask of quicksilver from the rich ore at Almaden, Spain, which in 1915 yielded an average of 9.04 per cent of quicksilver, was about $12. This at first glance seems very low but is not at all extraordinary when it is considered that this ore is more than twenty-three times as rich as the average ore treated in California and that consequently a flask of quicksilver can be obtained with less than one-twentieth of the labor necessary in that State and with that labor paid for at much lower wages. At Monte Amiata, in Italy, on ores averaging in 1913 0.89 per cent the cost of producing a flask appears to have been about $30. In that district the annual production of metal per man in that year is given as 40.5 flasks for the Abbadia San Salvatore mine and 23.6 flasks for the district as a whole. At Idria, in Austria, the cost, prior to the war, on ore averaging 0.65 per cent, was about $23 a flask.

PRICES.

The domestic price of quicksilver remained high enough throughout 1917, owing chiefly to the demand for war uses, to offer considerable profit to those operators fortunate enough to be in ore and to have the equipment for mining and reducing it. The highest price reached in San Francisco was $140 a flask during the latter part of February, and the lowest quotation in the same market was $80 in January. The price of $105 a flask fixed for Government purchases at the Mare Island Navy Yard, Cal., or of $105.75 in New York, became effective at the beginning of April. About 40 per cent of the output of the principal mines was requisitioned at this price, and this action, although it has not directly interfered with the movement of prices in the open market, has doubtless tended to stabilize them.

The prices given in the following table for the United States and the United Kingdom have been obtained by averaging the weekly quotations published in the Mining Journal, for London; the Engineering and Mining Journal, for New York; and the Mining and Scientific Press, for San Francisco, the primary domestic market. As the figures prior to 1913, however, are not complete in the Mining and Scientific Press, they have been taken, for the years 1907–12, inclusive, from the Engineering and Mining Journal. Obviously, the figures given in this table, being annual averages, may differ considerably from the price actually quoted or obtained on a particular date.

Average yearly prices of quicksilver in the United States and the United Kingdom from 1907 to 1917, inclusive.

[Per flask of 75 pounds.]

Year.	San Francisco[a] (domestic).	New York.[b]	London.[c]			Year.	San Francisco[a] (domestic).	New York.[b]	London.[c]		
			£	s.	d.				£	s.	d.
1907	$39.60	$41.50	7	0	6	1913	$40.23	$39.54	7	9	2
1908	44.17	44.84	8	4	8	1914	49.06	48.31	[d]7	15	0
1909	45.45	46.30	8	12	0	1915	85.80	87.01	14	10	8
1910	46.51	47.06	8	16	0	1916	125.89	125.49	17	2	10
1911	46.01	46.54	8	4	11	1917	105.32	106.30	22	4	3
1912	42.05	42.46	8	2	10						

[a] Min. and Sci. Press, San Francisco.

[b] Eng. and Min. Jour., New York.

[c] Min. Jour. (London).

[d] Metal exchange closed about three months after outbreak of war. Average based on 37 weeks only.

The table below shows average monthly quotations, as published in the Mining and Scientific Press.

Figures 4 and 5 show the variations in prices during the years indicated.

Prices of domestic quicksilver at San Francisco, 1915–17.

[Per flask of 75 pounds.]

Month.	1915	1916	1917	Month.	1915	1916	1917
January	$51.90	$222.00	$81.00	July	$95.00	$81.20	$102.00
February	60.00	295.00	126.25	August	93.75	74.50	115.00
March	78.00	219.00	113.75	September	91.00	75.00	112.00
April	77.50	141.60	114.50	October	92.90	78.20	102.00
May	75.00	90.00	104.00	November	101.50	79.50	102.50
June	90.00	74.70	85.50	December	123.00	80.00	117.42

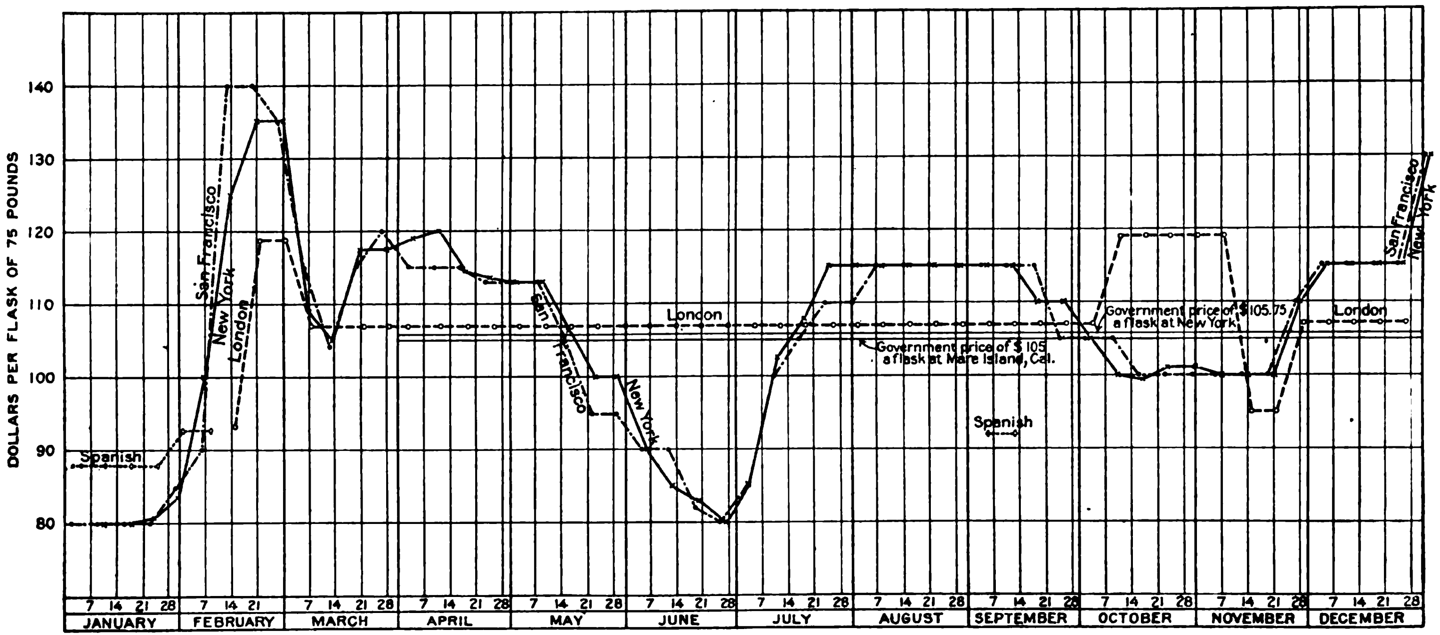


FIGURE 5.—Diagram showing prices of quicksilver in London, New York, and San Francisco in 1917. The Mining Journal, of London, occasionally quotes prices on "Spanish quicksilver." In January and for the first two weeks in February it quoted "Spanish quicksilver" only. In September it gave two quotations on "Spanish quicksilver" in addition to those on "quicksilver." All these quotations are represented in the diagram.

Although San Francisco is commonly looked upon as the "primary market" for quicksilver in the United States, from the fact that the greater part of this metal produced in the country comes from the Pacific coast and goes through the hands of San Francisco firms, yet it should be noted that that city is not a market in the same sense as New York. Most of the quicksilver that passes nominally through San Francisco is handled on commission and is sold in New York, which consequently is the great distributing point of quicksilver to the actual consumers.

IMPORTS AND EXPORTS.

The import duty on quicksilver from 1890 to 1895 was 10 cents a pound. From 1895 to 1913 it was 7 cents. The Underwood tariff bill enacted in 1913 and still in force made the duty 10 per cent ad valorem, which at the average price in London for 1917 would be equivalent to an import tax of about 14 cents a pound.

In the following tables[1] are given imports of quicksilver for domestic consumption, total annual exports, and annual exports by countries. In 1917 the imports were less by 33,902 pounds, or about 452 flasks, than in 1916, and the decrease in the total value of the imports was $67,887. The exports increased by 1,898 flasks, with an increase in value of $327,995. About 34.5 per cent of the total exports went to Canada, to be used chiefly in the manufacture of fulminate and glacial acetic acid for war purposes.

Quicksilver imported and entered for consumption in the United States, 1908–1917.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1908	15,113	$8,216	1913	171,653	$75,361
1909	15,968	8,203	1914	614,869	271,984
1910	667	381	1915	421,884	282,752
1911	471,944	251,386	1916	424,396	515,919
1912	82,706	39,920	1917	390,494	448,032

Quicksilver exported from the United States, 1908–1917.

Year.	Quantity (flasks of 75 pounds).	Value.	Year.	Quantity (flasks of 75 pounds).	Value.
1908	2,996	$124,960	1913	1,140	$43,574
1909	6,802	266,243	1914	1,446	70,753
1910	1,923	91,077	1915	3,372	225,509
1911	291	13,995	1916	8,880	670,475
1912	310	13,360	1917	10,778	998,470

---

[1] Prepared by J. A. Dorsey from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Domestic quicksilver exported from the United States, 1916–17, by countries.

Country.	1916		1917	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Europe:				
Azores, and Madeira islands	....	....	100	$124
Denmark	1,020	$1,595	....	....
England	246,034	216,301	92,314	101,825
France	825	487	9,543	11,040
Netherlands	4,821	5,096	375	400
Norway	....	....	9,365	14,998
Russia in Europe	1,512	1,520	....	....
Scotland	15,000	15,300	....	....
Spain	50	34	126	148
Sweden	5,625	7,200	....	....
North America:				
British Honduras	10	48	20	23
Canada	71,759	90,745	279,358	372,759
Mexico	91	159	815	1,059
Newfoundland	....	....	175	206
Central America:				
Costa Rica	164	181	292	362
Guatemala	300	420	270	329
Honduras	75	96	....	....
Nicaragua	834	1,298	1,152	1,628
Panama	87	51	....	....
Salvador	75	105	150	265
West Indies:				
British—				
Jamaica	....	....	55	69
Cuba	1,422	1,506	1,127	1,287
Dominican Republic	88	90	90	99
Dutch	....	....	20	34
French	....	....	158	220
South America:				
Argentina	1,636	1,863	1,515	2,397
Brazil	966	872	119	161
Chile	823	1,331	225	329
Colombia	990	1,185	329	406
Ecuador	000	681	675	936
Guiana—				
British	....	....	200	230
Dutch	615	630	....	....
French	600	531	3,111	4,521
Peru	2,787	3,933	375	259
Venezuela	2,136	2,364	225	240
Asia:				
China	9,005	9,950	....	....
China, British leased territory	....	....	3,750	4,700
Chosen (Korea)	150	150	1,650	2,426
British East Indies	....	....	90	100
Dutch East Indies	150	150	1,242	1,288
Hongkong	49,275	55,206	142,850	171,415
Japan	241,025	234,197	178,625	196,962
Russia in Asia	2,700	2,850	5	12
Oceania:				
British—				
Australia	675	685	33,365	43,077
New Zealand	....	....	9,525	10,083
Philippines	352	381	455	518
Africa:				
British South Africa	1,050	1,078	34,500	51,600
Portuguese South Africa	1,200	1,256	....	....
	666,027	670,475	808,336	998,470

Manufactured products containing quicksilver imported for consumption in the United States in 1916–17.

	1916		1917	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Fulminate:				
For mining	....	....	....	$75,839
For other uses	....	$229,194	....	1,848,802
Vermilion reds	58,635	79,411	16,751	24,441
Calomel, corrosive sublimate, and other mercurial chemical preparations	....	19,874	....	4,155

USES OF QUICKSILVER.

The following are the principal uses of quicksilver under normal conditions, stated in general order of decreasing importance. Quicksilver enters largely into the manufacture of drugs and chemicals, including calomel and corrosive sublimate. Mercuric oxides and mercury salts are also used extensively in the manufacture of certain chemicals, such as glacial acetic acid, phthalic acid, and phthalic anhydride, into which mercury does not itself enter. Mercury fulminate, with the chemical formula $Hg(CNO)_2$, is used as a detonator for high explosives,[1] and to a less extent than formerly in small-arms ammunition. It is made by treating mercury with strong nitric acid and alcohol.

The discovery of mercury fulminate by Howard in 1799 led to the invention of the percussion cap in place of the old flintlock, and fulminate still remains the best-known and most-used detonator for gunpowder and high explosives. It is often combined with other substances, particularly with an abrasive, such as powdered glass, to increase its sensitiveness, and with compounds or mixtures that themselves have the property of detonating, such as sulphide of antimony and chlorate of potassium. Recently a large part of the mercury fulminate in detonators for modern high explosives has been replaced by picric acid, trinitrotoluene, or tetranitromethylamine, whereby a much stronger initial effect is obtained and one part of mercury fulminate is made to detonate a charge that would have required six times as much fulminate used alone. Other substances have been found also which seem likely to replace mercury fulminate entirely for certain uses. One of these is lead azide, a salt of hydronitric acid. Large dry crystals of this salt are so sensitive as to explode when brushed with a feather, but smaller crystals are less sensitive. Other proposed substitutes are lead styphnate, $PbC_6(NO_2)_{12}O_2$; hexamethylamine triperoxidediamine, $(N(CH_2O.OH_2C)_3N)$, said to be four or five times as strong as mercury fulminate; nitrogen tetrasulphide, N_4S_4; diazobenzolnitrate, $C_6H_5N_2(NO_3)$; basic mercury nitromethane; and perchlorate of trimercuraldehyde.[2]

As mercuric sulphide, mercury forms the brilliant red pigment vermilion. The metal is employed extensively in electrical apparatus, including recitifiers for changing alternating into direct current, mercury-vapor lamps,[3] and storage batteries. In the manufacture of felt hats from rabbit's fur, mercuric nitrate is used to roughen the hairs so that they will adhere together, a process technically known as "carroting." Metallic quicksilver is employed in the amalgamation of gold and silver ores, although of late years the wide application of the cyanide process has decreased this use. In the metallic state, also the metal is utilized in the manufacture of instruments, thermostats, gas governors, and other appliances. Mercury enters into the composition of some antifouling marine paints for ship bottoms, a modern and at present a rapidly increasing use. The mercury for this purpose is generally employed as the red mercuric oxide, its efficacy depending upon the gradual conversion of the oxide to the poisonous bichloride by the sodium chloride of salt water. About 12 ounces of mercuric oxide or 11 ounces of metallic mercury is contained in each gallon of paint, which covers 243 square feet. Mercury is also used in certain compounds for preventing boiler scale, in cosmetics, and in dental amalgam. Silver nitrate has to a large extent been substituted for mercury in silvering mirrors. A small quantity of quicksilver, not more than 2 or 3 flasks annually, is used in floating certain types of revolving lights in lighthouses. The quicksilver so used, like that in some instruments and appliances, such as gas governors, is not consumed in the ordinary course of events, and additional quantities are required only when new installations are made. Quicksilver is also used as the cathode in certain electrolytic processes for manufacturing chlorine and caustic soda from common salt. The quicksilver combines with metallic sodium as sodium amalgam, which, in the presence of water, immediately reacts and forms metallic mercury and sodium hydrate. Mercuric oxide parts with oxygen readily and is a useful oxidizing agent in certain chemical processes. An important modern utilization of this property is in the manufacture of glacial acetic acid by the oxidation of acetylene.

---

[1] Detailed specifications for mercury fulminate for military use have been prepared for the Ordnance Department, U. S. A., by H. C. Pritham, chief chemist, Frankford Arsenal; Dr. C. G. Storm, design section, Ordnance Department; and Capt. Paul McMichael, design section, Ordnance Department.

[2] Most of the statements in this paragraph are taken from a paper by Walter Arthur (Initiation of explosives: Jour. Ind. and Eng. Chemistry, vol. 9, pp. 392–395, 1917). Some of the chemical formulas are too complex to reproduce here.

[3] The light from the mercury-vapor quartz lamp is rich in violet rays, which fact gives the lamp its well-known usefulness in photography. It is also a source of ultra-violet rays, but, as glass is opaque to these rays, the lamp, to be effective, must be inclosed in quartz instead of glass. The ultra-violet rays are destructive to the lower forms of life and advantage is taken of this property by using quartz-inclosed, mercury-vapor lamps to sterilize the water supplied to some of the cities in Europe, particularly Marseille and Lunéville in France and Leghorn and Pisa in Italy. A description of the apparatus used and the method followed is given in "Water supply," by W. P. Mason, 4th ed., New York, 1916, pp. 202–206, and in "Water purification plants and their operation," by M. F. Stein, New York, 1916, p. 174. See also Recklinghausen, M. von, Sterilization of water by ultra-violet rays of the mercury-vapor quartz lamp: Am. Inst. Elect. Eng. Proc., vol. 33, pp. 1049–1062, 1914.

Experiments have been carried out on a considerable scale to determine the possible advantage of using mercury vapor as proposed by W. L. R. Emmet[1] in tandem mercury and steam boilers with turbine power generators. These are reported to have been encouraging and a 4,000-kilowatt unit has been built by the General Electric Co. to test further this application. The mercury so used is recoverable, except for incidental losses, but nevertheless if this invention leads in practice to as great an increase of power or economy of fuel, 45 per cent, as the experimental work has indicated, it is likely to result in a large consumption of the metal.

From data collected chiefly by J. P. Dunlop, under the supervision of H. D. McCaskey, both of the Survey, it is estimated that the principal purposes for which quicksilver was used in the United States in 1917 were as follows:

	Flasks of 75 pounds.
Drugs and chemicals	8,500
Fulminate	4,850
Vermilion	3,130
Oxide (for antifouling marine paint)	3,000
Electrical apparatus (batteries, electrolyzers, rectifiers, lamps, etc.)	2,700
Felt manufacture (especially hats)	1,700
Gold and silver amalgamating mills	850
Instruments, thermostats, gas governors, automatic sprinklers, etc	630
Miscellaneous, including boiler compounds and cosmetics	1,000
	26,360

---

[1] See bibliography.

It is estimated that the nonmilitary uses alone, if unrestricted, will require about 23,260 flasks in 1918, and that the Government requirements, partly to be met from abroad, will even exceed this quantity.

CONSUMPTION OF QUICKSILVER IN GOLD AND SILVER MINING.

Quicksilver is utilized to amalgamate with and retain native gold, both in quartz milling and in placer mining. Under ideal conditions the metal so employed would be recoverable and could be used over and over. In practice, however, there is some loss, which, according to Sharwood,[1] who has given this subject careful study, usually ranges from 0.005 to 0.01 pound avoirdupois, or from 0.07 to 0.15 ounce troy, to each ton of low-grade ore treated in modern mills. The following table gives approximately this loss for each State, including probably some quicksilver purchased during the year for new or enlarged milling operations. The figures given for Alaska are the least reliable, as they are based for the most part on statements of the cost of the quicksilver consumed annually in the large mills on Douglas Island with small, arbitrarily assumed additions for the smaller mills in the Territory. In the summer of 1916 amalgamation on Douglas Island was replaced by the cyanide process.

Quicksilver consumed in gold-quartz milling in United States, 1912–1916, in pounds.

State.	1912	1913	1914	1915	1916
Alaska	[a]7,700	[a]7,500	[a]7,500	[a]5,750	[a]7,750
Arizona	[b]1,400	[b]1,500	[c]1,802	[c]547	[c]645
California	[d]24,200	[d]17,000	[d]17,500	[d]19,600	[d]19,300
Colorado	[e]10,622	[e]10,834	[e]6,059	[e]6,014	[e]5,237
Idaho	[f]700	[f]254	[f]598	[f]1,040	[f]1,183
Montana	[b]750	[b]200	[c]408	[c]371	[b]206
Nevada	[b]1,500	[b]1,600	[b]6,826	[c]4,367	[c]2,111
New Mexico	[e]187	[e]133	[e]365	[e]368	[e]280
Oregon	[b]260	[b]350	[b]400	[d]1,690	[d]3,700
South Dakota	[e]14,095	[e]12,160	[e]13,500	[e]13,900	[e]12,516
Utah	[b]40	[b]30	[b]20	[c]30	[c]15
Washington	[f]121	[f]130	[f]43	[f]28	[f]317
	61,575	51,691	55,021	53,705	53,260

[a] Rough estimate based on cost of quicksilver consumed as given in annual reports of Alaska gold-mining companies (F. L. Ransome).

[b] Estimate based on bullion produced by amalgamation (H. D. McCaskey).

[c] Heikes, V. C., U. S. Geol. Survey Mineral Resources, 1912–1916.

[d] Estimate based on bullion produced by amalgamation (F. L. Ransome).

[e] Henderson, C. W., U. S. Geol. Survey Mineral Resources, 1912–1916.

[f] Gerry, C. N., idem.

The quantity of quicksilver used in sluicing, hydraulic mining, and dredging, and the proportion of it lost, vary widely with the character of the gravel and the coarseness of the gold. In modern gold dredging the quantity lost annually by each dredge is very small, and according to William S. Noyes,[2] of the El Oro Dredging Co., averages, roughly, about a flask. An attempt was made to estimate the quantity lost annually in placer mining in each State and to prepare for this branch of the mining industry a table similar to that just given, but the data available proved insufficient for this purpose. Probably from 15,000 to 20,000 pounds, or from 200 to 265 flasks, is lost annually in California in placer mining, including dredging, and possible twice as much in the country as a whole.

---

[1] Sharwood, W. J., Loss of quicksilver in gold mills: Min. and Sci. Press, Apr. 6, 1918, p. 483.

[2] Letter, Aug. 12, 1918.

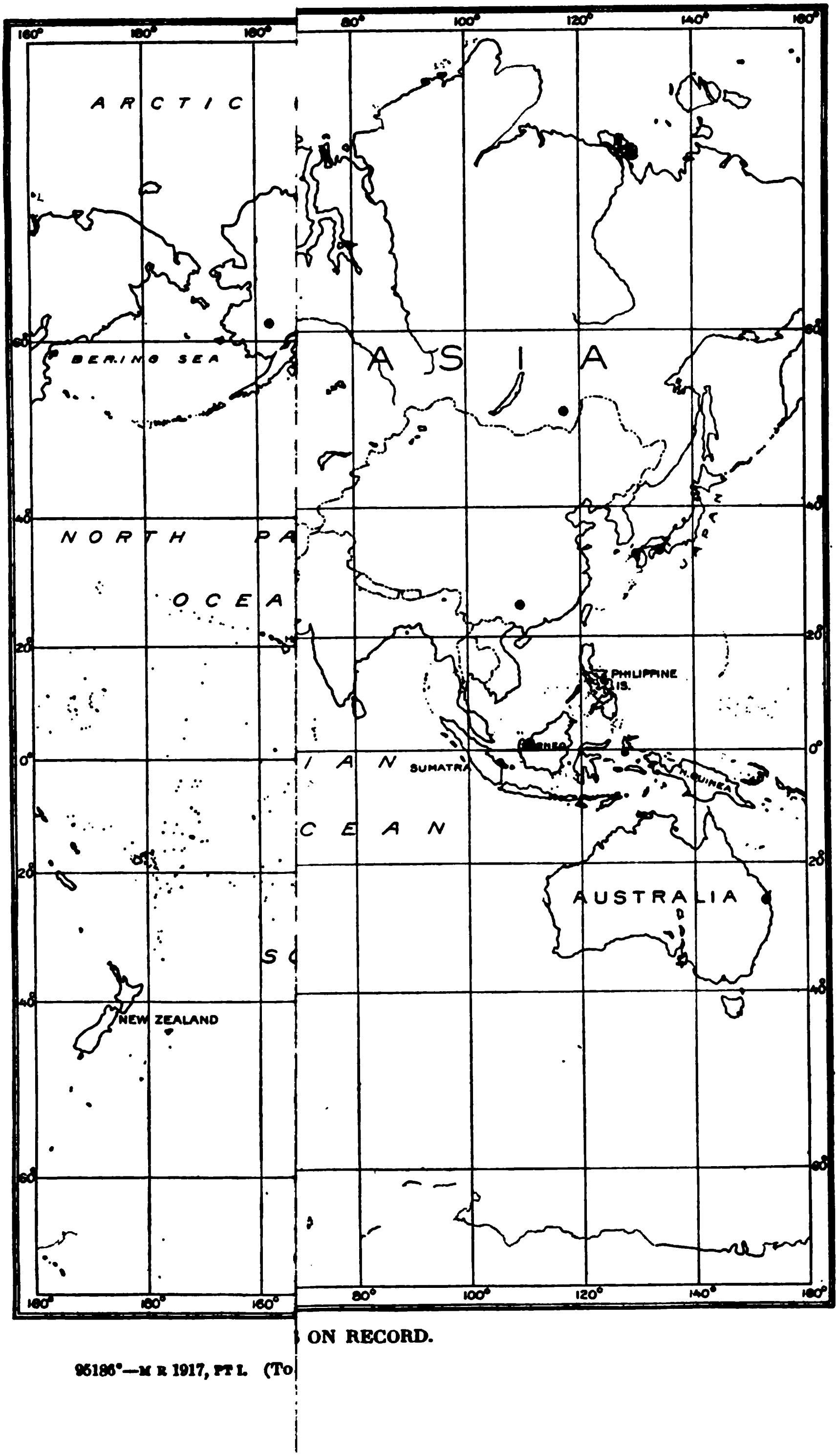
GENERAL GEOGRAPHIC AND GEOLOGIC RELATIONS OF QUICKSILVER DEPOSITS.

IN THE WORLD AS A WHOLE.

The ores of quicksilver, like those of most metals, show on the whole a close association with igneous rocks and with zones of fissuring. More commonly than with other metals, with the possible exception of antimony, they are associated with volcanism as opposed to plutonic igneous activity and were deposited comparatively near the surface. It follows that quicksilver deposits as a rule are found in regions of Tertiary and Quaternary volcanic activity which have not been subjected to long and deep erosion, that they are more likely to be in the younger geologic formations than in the older rocks, and that as a class, compared, for example, with the hypogene ores of gold or copper, they do not extend to great depth. It must be noted, however, that there are some conspicuous exceptions to these generalizations. Although California deposits are in a region of late volcanic activity and many of them are closely associated with active hot springs, the ore bodies at present most productive in that State, those at New Idria (Idria post office) and the great deposits which formerly yielded so richly at New Almaden, have no obvious connection with volcanism. The same is true of many smaller deposits in that State. The quicksilver deposits in Arizona, not yet more than nominally productive, are in pre-Cambrian schist and are by no means clearly associated with volcanic activity. The greatest quicksilver mine in the world, that at Almaden, Spain, has no known connection with vulcanicity or massive igneous rocks, has been worked to a depth of 1,150 feet, and the ore bodies have been found to grow larger and richer downward. The deepest quicksilver mine in the world is the New Almaden, in California, worked to a depth of 2,200 feet. The part of the mine below the 800-foot level was abandoned at a time when the price of quicksilver was low, but it is doubtful whether under any conditions that can now be foreseen it will be profitable to reopen and work the deep levels of this mine. The ground at that depth is difficult to hold and mining is interfered with by abundant water and gas.

Although most of the known quicksilver deposits (Pl. II) are in regions of geologically late volcanic eruptions, it is probable that ores of quicksilver were deposited during or closely following epochs of similar igneous activity in the older geologic periods, but that many of them have been removed by erosion. Some of the deposits in the older rocks, which do not appear to be related to Tertiary or later volcanic eruptions, may have had such earlier origin.

The quicksilver deposits of the Adriatic region in Europe, including those at Idria in Austria, Avala in Serbia, and Monte Amiata in Italy, have been shown by De Launay to belong to a single metallo-


ARCTIC
BERING SEA
NORTH PA
OCEA
ASIA
PHILIPPINE IS.
BORNEO
SUMATRA
N. GUINEA
IAN
CEAN
AUSTRALIA
NEW ZEALAND
S
160°
180°
160°
80°
100°
120°
140°
160°
60°
40°
20°
0°
20°
40°
60°

ON RECORD.

95186°—M R 1917, PT I. (To

genetic province characterized by Tertiary eruptions. Similarly, the somewhat scattered occurrences of quicksilver in Alaska, Washington, Idaho, Montana, Oregon, Nevada, Utah, California, Arizona, Mexico, Peru, and Chile coincide in part with the belt of Tertiary and Quaternary volcanic activity along the western sides of the continents of North America and South America. Future work may subdivide this belt into two or more provinces as regards the genesis of the quicksilver deposits, but existing knowledge is insufficient for such distinction. The deposits at Almaden, Spain, in the Donetz Basin, Russia, in Asiatic Turkey, and in China appear to be isolated occurrences that can not at present be assigned to recognizable provinces of eruptive activity and metallization.

The quicksilver deposits themselves are not confined to rocks of any particular kind or of any particular geologic age. At Almaden, in Spain, the ore bodies have been formed by the impregnation and displacement of quartzite beds that lie between clay slates, all of Silurian age. At Oviedo, in the same country, cinnabar, with pyrite, orpiment, and realgar, occurs in brecciated sandstone and shale of Carboniferous age. At Idria, in Austria, the ore consists chiefly of Triassic shale, sandstone, and dolomite impregnated with cinnabar near a zone of overthrust faulting and was deposited in post-Eocene time. In Tuscany, in Italy, the principal ore bodies are in Eocene limestones and shales, close to a contact between them and trachyte. In California most of the deposits are in the sedimentary rocks of the Franciscan group, probably of Jurassic or early Cretaceous age, and in the serpentine associated with the Franciscan. The New Almaden ores, contrary to previously published descriptions, are wholly in serpentine, and the New Idria ores are in sandstone and shale. In Nevada most of the deposits are in Tertiary rhyolite, although some are in Triassic or Jurassic limestone. The only important mine in Oregon is in andesite, presumably of Tertiary age. The Texas ores are in massive Lower Cretaceous limestone and in Upper Cretaceous limestone and shale (Eagle Ford). They are closely associated with small bodies of intrusive rocks of various kinds. Some of the deposits in Mexico appear to be geologically similar to those in Texas. The formerly very important deposits at Huancavelica, in Peru, are in Cretaceous or Jurassic shales, conglomerates, sandstones, and limestones, especially in sandstone, in close proximity to andesitic intrusive rocks.

IN THE UNITED STATES.

It is entirely in accord with the general association of quicksilver ores with volcanic activity that the quicksilver deposits of the United States (Pl. III) are found in the western part of the country, where the products of Tertiary and later volcanism abound, and where numerous hot and thermal springs testify to the comparative recency of much of the igneous activity.

The most abundant and productive deposits are in California. Western Texas comes next in productivity, followed by Nevada. Oregon, Arizona, Washington, Idaho, Montana, Utah, and Wyoming are all known to contain some quicksilver deposits, although Oregon is the only one of these States in which the metal is at present being produced steadily on a commercial scale.

In California the principal deposits occur in the Coast Ranges, within a belt about 400 miles long that extends from Santa Barbara on the southeast to Ukiah on the northwest. The maximum width of this belt is about 75 miles. The known occurrences within this area are numerous. About 25 of them are at present productive, while it is estimated that at least three times that number of mines, which were productive in the past, are now idle. A comparatively small number of deposits are prospects, from which no production has yet been recorded. There are a few deposits of quicksilver ore in California outside of the belt mentioned, but these are of comparatively small economic importance.

With a few exceptions, the deposits of the main quicksilver belt in California are in rocks of the Franciscan group, probably of Jurassic age, or in the serpentine, which is such an abundant and characteristic associate of these rocks and which is the alteration product of irruptive rocks of the peridotite group, rich in magnesium and iron.

Probably the greater number are in the serpentine. Others are in sandstone, generally near the serpentine, and still others are in thin-bedded siliceous rocks known as radiolarian chert. The most notable exceptions to the occurrence of ore within the serpentine and Franciscan group are the deposits of the Oceanic mine, near Cambria, San Luis Obispo County, and of the Sulphur Bank mine, in Lake County. The ore of the Oceanic occurs in fine-grained sandstone, probably Miocene, that is faulted against the Franciscan, and the ore at Sulphur Bank occurs partly in basalt and accompanying local detrital deposits that lie upon the Franciscan and partly in the Franciscan itself.

Some of the mines, not all at present productive, in which the ore is wholly or partly in serpentine are the Elgin, Wide Awake, Empire, and Central, in Colusa County; the Abbott, Baker, Big Injun, Chicago, Great Western, Helen, Mirabel, and Wall Street, in Lake County; the Aetna, Bella Union, Corona, Knoxville (Redington), La Joya, and Twin Peaks, in Napa County; the Culver-Baer, Great Eastern, and Rattlesnake, in Sonoma County; the January (Harrison) and Reed, in Yolo County; the New Almaden and New Guadalupe, in San Clara County; the Patriquin, in Monterey County; the Alpine, Aurora, Cerro Bonito, Flint (Fourth of July), Los Picachos, and San Carlos (the New Idria Quicksilver Mining Co.), in San Benito County; the Belt (La Libertad), Cambria, Keystone, Little Bonanza, Tartaglia, and Huasna, in San Luis Obispo County; the Acachuma and Los Prietos, in Santa Barbara County; and the Mercy, in Fresno County. In some of these mines the serpentine is present only as narrow dikes or tongues entirely altered to one of the varieties of "quicksilver rock," which to the inexperienced eye may not be recognized as having once been serpentine. Mines in which the ore occurs wholly or partly in sandstone or shale are the Manzanita, in Colusa County; the Sulphur Bank, in Lake County; the Oat Hill, in Napa County; the Eureka and Socrates, in Sonoma County; the New Idria, Wonder, Florence Mac, Cerro Bonito, and Del Mexico, in San Benito County; and the Oceanic, Klau, and Capitola, in San Luis Obispo County. Mines in which the ore occurs wholly or in part in radiolarian chert are the Great Western and Big Chief, in Lake County, and the Cloverdale, in Sonoma County. Mines in which the

E UNITED

ore occurs in unserpentinized dikes or small intrusive masses are the Star and Silver Bow workings of the Aetna mine, in Napa County; the St. Johns, in Solano County; the Cuddeback, in Kern County; and, to a small extent, the New Idria, in San Benito County. Mines in which the ore occurs partly or wholly in lava or tuff are the Sulphur Bank, in Lake County; the Manhattan, in Napa County; and probably the Brownlie and Hastings, in Solano County, although the exact nature of the ore-bearing rock of these two mines is as yet in doubt.

In Oregon cinnabar is widely distributed, but only one deposit, the metallized fissure zone in andesite at Blackbutte, in Lane County, is at present commercially productive.

In Washington cinnabar has been found at a few localities in Chelan, Kittitas, and Lewis counties. None of the deposits has yet proved to be of economic importance.

Nevada contains many widely scattered deposits of quicksilver ore, no one of which has yet been worked on an extensive scale, although a few of them have been fairly productive for short periods. The Nevada quicksilver ores occur in rhyolite of Tertiary age and in various limestones or associated sedimentary beds of Paleozoic and Mesozoic age. The deposits in rhyolite include that in Sheep Canyon, 1½ miles southeast of Ione, in Nye County; those at Ivanhoe Springs, in Elko County, 50 miles northwest of Elko; at Goldbanks, in Humboldt County, 30 miles south of Winnemucca; at Montgomery Mountain, in Mineral County, 5 miles east of Montgomery station on the narrow-gage railway from Mina, Nev., to Keeler, Cal.; and, in part, the deposits on Bare Mountain, 6 miles east of Beatty, in Nye County. This ore in rhyolite is generally very hard and siliceous, although less so near Ione and on Montgomery Mountain than at the other localities mentioned. The quicksilver occurs chiefly in the mineral cinnabar distributed unevenly and in places very erratically through the altered rhyolite.

The deposits occurring in limestone or dolomite, or in sedimentary beds associated with limestone, include that near the head of Shamrock Canyon, near Ione; those in the Humboldt Range east and northeast of Lovelock, in Humboldt County; in part those near Beatty; and those in the Pilot Mountains, 8 miles a little south of east from Mina, in Mineral County.

In Arizona most of the known quicksilver deposits occur in zones of fissuring or shearing in pre-Cambrian schist. Such are the deposits in the Mazatzal Mountains, Maricopa and Gila counties, which have yielded some quicksilver but have not yet been made continuously productive, the deposits 15 miles north of Phoenix now being developed and the lode of the Colonial Mining Co., near Quartzite, in Yuma County, at present unworked, although it has produced some quicksilver. The occurrence of cinnabar in Skull Valley, in Yavapai County, west of Prescott, has been known for many years. The mineral is said to be in a fissure vein in granite. No production is recorded from this locality.

In Texas the principal quicksilver deposits are in the Terlingua district, in Brewster County, about 75 miles south of Alpine. The ore occurs along fissure zones in Cretaceous limestones and shales, generally in proximity to bodies of intrusive rock.

MINERALOGY OF QUICKSILVER ORES.

GENERAL CHARACTER OF ORES.

Quicksilver ores as a rule are comparatively simple in mineralogical character. About 25 mercurial minerals are known, but most of them are rare, and to few quicksilver miners does "quicksilver ore" suggest anything but rock containing the brilliant red sulphide cinnabar, with perhaps some native mercury and possibly a little of the black or dark-gray sulphide metacinnabar. These minerals are commonly associated with more or less iron sulphide in the form of pyrite or marcasite. The mercury minerals and associated sulphides may be scattered in small specks through sandstone or other porous rock; they may occur as irregular streaks or bunches in altered rocks of various kinds; or, with calcite, barite, or quartz as gangue minerals, they may form definite veins, although these are rarely of regular form.

A large number of the deposits in California are in serpentine, and in these the cinnabar and accompanying sulphides occur in dark opal or in carbonates of calcium, magnesium, and iron, or in mixtures of opal and carbonates. In Nevada many of the deposits are in rhyolite, which in the vicinity of the cinnabar is generally much altered. In some localities the rhyolite has been changed to a very hard granular rock resembling quartzite, in others it has been converted to white opal, and in others to soft masses of sericite or kaolinite. Various mixtures of these minerals are also common.

In certain localities the sulphide of antimony, stibnite, is fairly abundant with the cinnabar, and most quicksilver deposits, especially in California, contain small quantities of an oily or asphaltic hydrocarbon.

MINERALS CONTAINING MERCURY.[1]

Amalgam.—A variable mixture of mercury and silver (Ag_2Hg_3 to $Ag_{36}Hg$), which crystallizes in the isometric system as dodecahedrons or modified cubes. It is silver-white with brilliant luster and from 3 to 3.5 in hardness.[2]

Amalgam carries from 26.4 to 95.1 per cent of silver. The mineral is rare, but has been found in Europe, Chile, British Columbia, and Colorado.

Lehrbachite.—A selenide of lead and mercury (PbSe with HgSe). Known only from the Harz Mountains in Germany.

Sphalerite.—Some varieties of zinc blende (ZnS) contain mercury, and from the sphaleritic zinc ores mined near Cologne, in Germany, quicksilver is obtained as a by-product.

---

[1] A few doubtful mineral species of which the composition is not accurately known and which may be mixtures, are omitted from this list. Such are "ammiolite" and "barcenite," supposed mercurial antimonates or antimonites.

[2] The Mohs scale, to which the hardness of minerals is commonly referred, is as follows:

1. Talc.
2. Gypsum (can be scratched with finger nail).
3. Calcite (can be cut with knife).
4. Fluorite.
5. Apatite.
6. Feldspar (can barely be scratched with good knife).
7. Quartz.
8. Topaz.
9. Sapphire.
10. Diamond.

Metacinnabar.[1]—The black sulphide of mercury (HgS) having the same composition as cinnabar and containing, when pure, 86.2 per cent of quicksilver. It is gray to black, with metallic luster, is brittle, and has a hardness of 3. The streak, or color of the powder, is black. Metacinnabar has been found in Germany, Mexico, and New Zealand, and has been an important source of quicksilver in some California mines. A little of the powdered mineral mixed with sodium carbonate (common soda) and heated in the bottom of a glass tube closed at one end will give a mirror-like ring of metallic quicksilver around the cooler part of the tube.

Guadalcazarite is a variety of metacinnabar containing a little zinc and selenium. It occurs in Guadalcazar, Mexico.

Leviglianite is reported to be another variety which contains iron and is found in Italy.

Tiemannite.—The selenide of mercury (HgSe). It is steel gray to black, with metallic luster, and crystallizes in complexly modified tetrahedrons of the isometric system. Its hardness is 2.5 and its specific gravity 8.19. This is a rare mineral but has been found in Germany and California and was formerly mined as an ore of quicksilver at the Lucky Boy mine in Piute County, Utah, where it is associated with barite, calcite, and manganese oxide.

Onofrite.—The sulphoselenide of mercury with the formula Hg (S, Se). It is dark gray to black, massive, fine granular, brittle, and has a hardness of 2.5. Its specific gravity is 8. The mineral is rare. It occurs with calcite and barite at San Onofre, Mexico, and was mined with tiemannite in Piute County, Utah.

Coloradoite.—The telluride of mercury (HgTe). It is iron black, inclining to gray, with metallic luster, is massive with granular texture, has a hardness of 3 and a specific gravity of 8.6. The mineral is rare. It occurs sparingly with gold-tellurium ores in Colorado and Western Australia.

" Kalgoorlite," a supposed telluride of gold, silver, and mercury from western Australia, has been shown to be probably a mixture of coloradoite and the gold-silver telluride, petzite.

Cinnabar.—The brilliant cochineal red sulphide of mercury (HgS), containing, when pure, 86.2 per cent of quicksilver. It crystallizes, like quartz, in the rhombohedral division of the hexagonal system. The crystals are transparent with adamantine luster, inclining toward metallic luster in some of the darker varieties. They have perfect cleavage parallel to the prism faces. The mineral also occurs as fine-grained aggregates of dull luster, although brilliant color. The crystals exhibit great variety of form from rhombohedral or thick-tabular to needle-like prisms. The hardness is 2 to 2.5 and the specific gravity from 8 to 8.2. The streak is scarlet. The characteristic color is sometimes masked by impurities, such as clay, iron oxide, or organic compounds. Minerals commonly associated with cinnabar are pyrite and marcasite, stibnite, native quicksilver, metacinnabar, sulphur, calcite, iron-magnesium carbonates, silica (as quartz, chalcedony, and opal), barite, and bituminous compounds. Less common associates are realgar (sulphide of arsenic), sulphides of copper, native gold, and fluorite. Cinnabar is the principal ore of quicksilver and at the present time is the source of more than 95 per cent of the metal produced in the United States. Its color and general physical properties make its recognition easy as a rule. Where its identity is in doubt the same simple test may be applied as for metacinnabar to establish the presence of mercury. As cinnabar darkens or even turns black on exposure, it may be necessary to break or scratch the mineral to reveal its characteristic red color.

---

[1] Inasmuch as cinnabar is almost universally used instead of cinnabarite there is apparently no good reason why this shorter form should not be employed in place of the more pedantic metacinnabarite.

Livingstonite.—A mercury sulphantimonite ($HgSb_4S_7$) which occurs in groups of slender prismatic crystals of bright lead-gray color and metallic luster. Its hardness is 2 and its specific gravity 4.81. The streak is red. It contains theoretically 24.8 per cent of mercury. Livingstonite is a rare mineral which has been reported only from Huitzuco and Guadalcazar, Mexico.

Tetrahedrite (variety schwatzite).—The mercurial tetrahedrite, a copper-mercury sulphantimonite ($4(Cu_2Hg)S,Sb_2S_3$), is dark gray to iron-black, with metallic luster but often dull. Its specific gravity is 5.1. It occurs in Hungary, where it has yielded quicksilver as a by-product in copper smelting, in Italy, and in the Blue Mountains of Oregon in gold ores. Schwatzite is a comparatively rare mineral and has not been recognized in quicksilver deposits, although the observations of Lindgren[1] on the relations of the mercurial tetrahedrite to cinnabar in the Blue Mountains led to his suggestion[2] that the cinnabar of the Plomosa district in Arizona may have been derived from schwatzite. It does not appear, however, that any considerable part of the cinnabar of the productive quicksilver deposits can have had this origin.

Calomel.—The mercurous chloride of mercury (Hg_2Cl_2), also known as horn quicksilver or horn mercury, crystallizes in the tetragonal system in pyramidal, prismatic, and tabular crystals, often complexly faceted. The color is white, gray, yellow, or brown, with adamantine luster. The hardness is between 1 and 2 and the specific gravity 6.48. Calomel is found sparingly in the quicksilver deposits of Europe, Mexico, and Texas. It is probably in all places a secondary mineral due to the action of atmospheric water on cinnabar.

Terlinguaite.[3]—A rare oxychloride (Hg_2ClO) in small monoclinic prismatic crystals with adamantine luster, as crystalline crusts and as yellow powder. The crystals are greenish yellow but turn olive-green on exposure. The mineral is brittle to sectile, with perfect cleavage. It has been described only from the Terlingua district, Tex., where it occurs as a secondary mineral in shallow workings associated with calomel, eglestonite, montroydite, kleinite, and mosesite.

Eglestonite.—The rare mercurous oxychloride (Hg_4Cl_2O) forms minute dodecahedral and octahedral crystals of the isometric system.

---

[1] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, p. 664, 1901. Also Mineral deposits, p. 801, New York, 1913.

[2] Bancroft, Howland, Notes on the occurrence of cinnabar in central western Arizona: U. S. Geol. Survey Bull. 430, p. 153, 1910.

[3] For full descriptions of this and other minerals occurring at Terlingua see Hillebrand, W. F., and Schaller, W. T The mercury minerals from Terlingua, Tex.: U. S. Geol. Survey Bull. 405, 1909.

They are yellow to brown with brilliant adamantine to resinous luster but darken on exposure and finally turn black. The mineral is brittle and has a hardness from 2 to 3 and a specific gravity of 8.3. It is known only in the Terlingua district with terlinguaite and other secondary mercury minerals.

Kleinite.—A rare mercury-ammonium chloride of uncertain formula which crystallizes in the hexagonal system in short yellow to orange crystals that darken on exposure but regain their original color in the dark. Its hardness is 3.5 and its specific gravity 7.9. It is a secondary mineral and occurs with terlinguaite.

Mosesite.—Another mercury-ammonium chloride, which crystallizes in small octahedra of the isometric system and has imperfect cleavage, uneven fracture, hardness slightly above 3, adamantine luster, rich lemon to canary-yellow color, and very pale yellow powder and streak. It occurs with terlinguaite.[1]

Iodyrite (variety tocornalite).—A rare iodide of silver and mercury, found only in Chile. It occurs in granular massive form and is of pale-yellow color, darkening on exposure. Another rather uncertain species originally described as an iodide of mercury but apparently containing chlorine and selenium has been named coccinite. It occurs at Casas Viejas, Mexico, in reddish-brown particles on a selenide of mercury.

Montroydite.—Mercuric oxide (HgO) occurs in long, slender prisms or as equidimensional or distorted crystals, of the orthorhombic system and as velvety crusts, of orange-red color. It is transparent, brittle and has a hardness between 1.5 and 2. It is associated with terlinguaite.

Magnolite.—A doubtful species supposed to be a tellurate of mercury (Hg_2TeO_4). Found as minute white silky crystals on coloradoite, in the Magnolia district, Colo.

TENOR.

The richest quicksilver ores worked on a large scale are those of Almaden, Spain, where the average content won from the ore in 1917 was nearly 7 per cent and where the average of some ore bodies is stated to be as high as 25 per cent. Probably the lowest tenor in ores that are successfully worked is found on the Pacific coast of the United States. The average content won from the California ores during the last two years is 0.38 per cent and the range, in furnace operations, in 1917, was from 0.17 per cent to 1.08 per cent. In Texas, in 1917, the average was 1.42 per cent and the range from 0.55 to 3.88 per cent. The ore at Idria, Austria, according to the latest information available, averages about 0.65 per cent. In the Monte Amiata district, Italy, the ores are reported to range in tenor from 0.25 to 30 per cent, the average for the district in 1913 being 0.89 per cent.

---

[1] Schaller, W. T., The properties of mosesite: U. S. Geol. Survey Bull. 509, pp. 104–109, 1912.

REVIEW OF QUICKSILVER DEPOSITS OF THE WORLD.

EUROPE.

Spain.—In Europe the largest and richest deposit of quicksilver ore known is at Almaden, in central Spain, about 125 miles south-southwest of Madrid and about 46 miles west-southwest of the town of Ciudad Real, in the Province of the same name. There are three nearly parallel ore bodies, trending east and west and standing vertically side by side, each consisting of a portion of a bed of quartzite impregnated with cinnabar. The beds of quartzite are separated by beds of clay slate. Along the south side of the ore bodies and their immediate inclosing rocks is a bed or layer of breccia of peculiar character locally called frailesca. This has been regarded by some geologists as a tuff. The rocks with which the ore is associated are all Silurian. The ore bodies are as much as 200 meters long and 12 meters wide. They have been mined to a depth of 350 meters, and have proved to become longer and wider with increasing depth. The main ore body is said to average from 14 to 15 per cent of quicksilver. The average content won from the ore in 1917 was nearly 7 per cent of quicksilver. The production in 1915 was 35,232 flasks (1,200 metric tons); in 1916, about 23,000 flasks; and in 1917, probably about 24,500 flasks. The mine is said[1] to have ore opened up that insures a future production of at least 40,000 metric tons of quicksilver.

The Almaden mine, whose output is such as in normal times to determine the market for quicksilver, has been owned and worked by the Spanish Government since 1645. The Government, on the basis of competitive proposals, contracts with the successful bidder for the sale of the quicksilver for periods of 10 years. For a number of successive periods the contract has been awarded to the Rothschilds of London, the present one dating from June 1, 1912. The contractors bind themselves to sell in London the greatest possible quantity of quicksilver, which they take f. o. b. at the reduction plant at Almaden, at prices above £7 per flask. They receive (1) a commission of 1¼ per cent of the amount of the sale; (2) 6s. for each flask shipped from Spain to London; and (3) 10 per cent of the amount by which the sales price exceeds £8 2s. per flask. The Spanish Government reserves from the operation of this contract 500 flasks annually for the national requirements of Spain. By this arrangement, although the mine is owned by Spain, the market has been controlled in London. At present the control of the sale of Almaden mercury has been taken over by the Admiralty through Messrs. Rothschild.

As regards the operation of the Almaden mine the following statement appeared in the Mining Journal (London) of August 4, 1917, page 492:

> We learn that the Cortes last year authorized the Spanish Treasury to appoint a committee to control the administration of the Almaden mines. It has been decided to put the working of the mines up for tender for a working period of not more than fifteen years.

---

[1] Sterner-Rainer, R., Der derzeitige Stand des Quecksilberhüttenwesens in Europa: Oesterr. Zeitschr. Berg- u. Hüttenwesen, vol. 62, p. 531, 1914.

Other productive deposits in Spain are those near Oviedo, in the Province of that name, about 20 miles south of the Bay of Biscay. Here the ore is described as occurring in Carboniferous sandstone and shale, particularly along zones of brecciation in these rocks. The principal deposit is described as up to 35 feet wide and several kilometers long. The ore contains cinnabar, pyrite, orpiment, and realgar. It is said to average about 0.3 per cent of quicksilver with arsenic compounds as by-products. According to a report from Vice Consul General H. A. McBride, written in Barcelona in 1911, the principal companies operating in the Oviedo district were the Oviedo Mercury Mines Co. (Ltd.), of London, the Sociedad Fábrica de Mieres, of Oviedo, and the Sociedad Unión Asturiana, of Mieres. The production from the district in 1915 was 608 flasks (20.7 metric tons).

A third group of deposits lies on the south slope of the Sierra Nevada in the Provinces of Granada and Almeria, southern Spain. These are described[1] as occurring in talc slates or schists of Triassic age, the cinnabar being accompanied by tetrahedrite and sulphides of nickel and cobalt. The production from Granada in 1915 was 41 flasks (1.4 metric tons).

Quicksilver has also been produced in a small way in the Province of Castellón, in eastern Spain. Other occurrences of cinnabar of slight or no economic importance are known in eastern Spain near La Creu in Valencia and near Orihuela in the adjoining Province of Alicante.

Portugal.—A small quantity of quicksilver was produced in Portugal in the nineteenth century from a mine near Conna, not far from Lisbon.[2]

France.—Cinnabar occurs at a number of localities in France and also in Corsica, but the deposits are not of economic character.

Germany.—In south Germany, north of Zweibrücken, in the Bavarian Pfalz (the ancient Palatinate), are quicksilver deposits which had considerable importance near the end of the thirteenth century, but the mines had been closed for many years at the beginning of the war. The deposits are described as veins and impregnations in Carboniferous shales and sandstones, in conglomerate, in melaphyre, and in rhyolite porphyry. They are said to have been very rich near the surface but to have become poor at depths less than 200 meters. Cinnabar and other mercurial minerals have been found at various localities in Germany, chiefly in deposits worked for other metals. The sphaleritic zinc ores mined near Bensberg, 15 kilometers east of Cologne, in the province of Rhineland, yield annually about 90 flasks of quicksilver, won as a by-product in zinc smelting.

Austria-Hungary.—In Austria-Hungary the principal deposit, owned by the Government, is at Idria, in the province of Krain, about 28 miles slightly east of north from Trieste, at the head of the Adriatic Sea, and 18 miles in a straight line from Gorizia. The ore bodies, of post-Eocene age, occur as veins, as more or less flat, horizontal masses, and as stocks, chiefly as impregnations of Triassic shale, fine-grained sandstone, and dolomite, and in the interstices of brecciated dolomite in the hanging wall of a great overthrust fault.

---

[1] De Launay, L., Traité de métallogénie: Gîtes minéraux et métallifères, vol. 3, p. 424.
[2] Calderón, D. S., Los minerales de España, vol. 1, p. 207, 1910.

The overthrust beds are complexly folded and rest on Cretaceous limestone. The ore bodies are very irregular in form and trend generally northwest-southeast, whereas the direction of the overthrust is southwest.[1] The ore is mineralogically simple, consisting of cinnabar in minute crystals, metacinnabar, with pyrite, calcite, dolomite, a little quartz, gypsum, and hydrocarbons (anthracite and idrialite). The deepest shaft is only 985 feet (300 meters) deep. In 1914 the Idria mine produced 23,832 flasks (811 metric tons). The output in Austria in 1916, probably all from Idria, is believed from the best information available to have been about 25,000 flasks. Reserves capable of yielding 20,000 metric tons, or 587,733 flasks, are known.

Other deposits in southern Austria (Krain) belonging to the same metallogenetic province as Idria are the Sanct Anna near Neumarkt, about 38 kilometers east of Laibach. These mines were formerly productive but were idle at the beginning of the war.

At Zips, near Iglo, in northern Hungary, quicksilver is obtained as a by-product from iron ore consisting of siderite which carries mercurial tetrahedrite and some cinnabar. The production in 1913 was 2,615 flasks. Cinnabar and other mercury-bearing minerals occur at a few other places in Austria-Hungary but not in economically important quanttiy.

Italy.—To the west of Idria quicksilver deposits belonging to the same general belt of metallization extend into northern Italy. The principal deposit of this belt in Venetia is the Vallalta, near Gosaldo, 95 kilometers north-northwest of Venice, close to the borders of the Tyrol. The deposit is described as occurring at a contact between quartzose porphyry and Triassic sandstone, shale, and conglomerate. The mine produced 9,550 flasks (325 metric tons) between 1856 and 1870 but has long been idle.

The most productive deposits of quicksilver in Italy are those of the Monte Amiata district. These are in Tuscany, in the province of Siena, about halfway between Rome and Florence. Monte Amiata is apparently a post-Pliocene volcano, and traces of recent volcanic activity survive in the issuance of gases and hot water.

The most recent and comprehensive account of these deposits is that of De Castro.[2] According to him, the mass of Monte Amiata consists of a rock termed trachyoligoclasite but commonly referred to as trachyte and locally called peperino, which has been erupted through shales and limestones from early Jurassic to late Tertiary age. The ore bodies of the district are so varied in form and occurrence that it is difficult to summarize their characteristics, but the principal deposits are found mainly as irregular masses and impregnations in Eocene limestones and shales close to the contact with the trachyte and particularly in brecciated and clayey material that has resulted from the crushing and alteration of the Eocene sedimentary beds by the trachytic eruption. There were eight producing mines in 1913, the most productive being the Abbadia-San Salvatore, which yields about 65 per cent of the output of the district. The district in 1916 yielded 32,129 flasks, and in 1917 about 29,300 flasks. Most of the metal before the war was exported to Great Britain and Germany and since the entry of Italy into the war has gone to Great Britain.

---

[1] Kropáč, Josef, Über die Lagerstättenverhältnisse des Bergbaugebietes Idria: Berg- u. Hüttenmän. Jahrb., vol. 60, pp. 97–146, 1912.

[2] Castro, C. de, Le miniere di mercurio del Monte Amiata: R. Ufficio geologico, Memorie descrittive della Carta geologica d'Italia, vol. 16, pp. 1–209, 1914.

The ore is cinnabar accompanied by pyrite, sulphides of arsenic and antimony, gypsum, and celestite. It ranges in tenor from 0.25 to 30 per cent, the average for the district in 1913 being 0.89 per cent. The coarse ore is treated in simple shaft furnaces and the fine ore in Cermak-Spirek furnaces, which are similar to the Scott furnace. The San Salvatore mine has fourteen 24-ton shaft furnaces, and four 24-ton and two 12-ton Cermak-Spirek furnaces. The annual production of metal per man was 1.378 metric tons, or 40.5 flasks, at the San Salvatore mine and 0.803 metric tons, or 23.6 flasks, for the district as a whole.

The most productive of the Monte Amiata mines are understood to have been under German control prior to the entry of Italy into the war but to have been seized by the Italian Government when it entered the conflict.

From Monte Amiata a belt of quicksilver deposits extends northwest between Florence and Pisa into the "Alpes Apuanes," but none of these has yet proved of economic value.

Serbia.—At Mount Avala, 20 kilometers southeast of Belgrade, deposits of quicksilver ore have been known since 1883. The ore, as described by Fischer,[1] occurs in a stocklike mass of quartz, opal, and siderite, which is a thermal alteration product of serpentine. The deposit thus resembles many of those in California. The Avala deposits were worked between 1889 and 1895 but have not fulfilled expectations and apparently have not been productive in late years.

Other occurrences of cinnabar are known in Serbia, Bosnia, and Albania but so far as known are not economically important.

Russia.—The only quicksilver deposits of note in European Russia are those near Nikitovka, in the Donetz coal basin, in the southwestern part of the Government of Woronesh, southern Russia.[2] The ore occurs as a network of small veins and as impregnations in much disturbed Carboniferous shales. The essential mineral is cinnabar accompanied by stibnite and pyrite. The deposits were discovered in 1879; the maximum output, 18,102 flasks (616 metric tons), was reached in 1897; and work was abandoned in 1911 but has been resumed since in a small way, according to reports. The ore mined in 1904 yielded 0.345 per cent of quicksilver; in 1905, 0.378 per cent; and in 1906, 0.276 per cent.

Quicksilver deposits are reported to have been worked in 1912 in the Government of Ekaterinoslaf, in southern Russia, and cinnabar is known to occur, closely associated with gold, about 20 miles from Neviansk on the eastern slope of the Urals in the Government of Perm.

ASIA.

Turkey.—The Konia mine in south central Asia Minor (Anatolia) is in silicified limestone. The quicksilver occurs as cinnabar, and most of the ore carries from 1 to 2.5 per cent of the metal, although portions of the ore body containing stibnite carry as much as 8 per cent. The known reserves were estimated in 1908 at 13,000 metric tons of 1 per cent ore.[1] The production in 1911 was only 90 flasks of 75 pounds. This mine reverted to the Turkish Government in 1912.

---

[1] Fischer, H., Die Quecksilberlagerstätten am Avalaberge in Serbien: Zeitschr. prakt. Geologie, vol. 14, pp. 245–256, 1906.

[2] The Donets basin is in what is now (October, 1918) Ukraine.

The Kara-Burnu mine, said to be the only important quicksilver mine in Turkey, is situated near Aidin, 30 kilometers southeast of Smyrna, in a region of Cretaceous limestones and Miocene basalt. The ore is worked by open-cut methods and averaged 0.33 per cent of quicksilver in 1912. In 1906 and 1907 the mine was producing about 3,000 flasks annually, but of late years the production has declined and in 1912 amounted to only 911 flasks (31 metric tons).

Russia.—The Ildekansk quicksilver mine, near Nertschinsk in southeastern Siberia, east of Lake Baikal, has gained ill-founded notoriety from the fact that political exiles were condemned to mine the ore, which occurs in small quantity as cinnabar with calcite and quartz in veins and bunches in limestone. The deposit appears to be of slight economic importance.

In several of the gold districts in Siberia cinnabar has been found in the auriferous gravels, but such occurrences appear to have led to the discovery of cinnabar in place only in the Ekaterinburg district, in the southern Urals.

China.—That quicksilver deposits occur in the Province of Kweichow, south-central China, has long been known, but the locality is remote from ordinary routes of travel and comparatively little is on record concerning their character. According to Brelich[2] the mines are in the prefecture of Toon-Yen and from 1,324 to 1,426 miles from Shanghai, according to the route taken. The ore bodies of the Wan San Chang mines are the most extensively worked. These occur in nearly horizontal magnesian limestone as (1) impregnations of particular beds, (2) along fissures and bedding planes, (3) as isolated bunches, and (4) as irregular disseminations through disturbed portions of the limestone. For several years prior to 1905 the output averaged about 4,000 pounds of quicksilver a month, with a small quantity of cinnabar marketed as such. This would be equivalent to about 640 flasks annually. More recent figures of production are not available.

Japan.[3]—Quicksilver ores occur at several localities in Japan, but the output is small and the Suigin mine at Suii, in Awa, Shikoku, appears to have been the only mine in operation in recent years. Here cinnabar associated with calcite is found along a fault fissure in Mesozoic limestone as veinlets and impregnations.

East Indies.—In Sarawak, Borneo, quicksilver has been produced from irregular deposits in shales and sandstones, the annual output, partly from placer operations, amounting to 1,733 flasks in 1872.[4]

Production is known to have continued until 1880, but no record of subsequent operations has been found. Cinnabar has been reported also from Sumatra and Java.[5]

---

[1] Monaci, E. P., Le miniere di mercurio in Turchia: Rassegna Min., 1908, p. 138.

[2] Brelich, Henry, Chinese methods of mining quicksilver: Inst. Min. and Met. Trans., vol. 14, pp. 483–496, 1905.

[3] Mining in Japan, past and present, pp. 107–108, Japan Bur. Mines and Dept. Agr. and Commerce, 1909. A list of localities with brief notes on modes of occurrence is given.

[4] Everett, A. H., Notes on the distribution of useful minerals in Sarawak. An undated pamphlet in the library of the United States Geological Survey; apparently written about 1874.

[5] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, p. 48, 1888. Becker, in the second chapter of this monograph, presents many notes on the foreign occurrences of quicksilver, many of which, however, relate to deposits of no known economic importance.

OCEANICA.

Australia.—Deposits containing quicksilver are known to occur along the coastal region of Queensland from Brisbane to Cape York and a few flasks have been produced from the Kilkivan district, near Gympie, in this region. The cinnabar is said to be found in lodes in granite, diorite, schist, altered sandstone and conglomerate, associated in some of the localities with serpentine. The deposits apparently are small and of low grade.[1]

In New South Wales deposits of doubtful economic value occur as lodes at Pulganbar, Yulgilbar, and Ewangar, near Grafton. A furnace was reported to be under construction at Pulganbar in 1913, but the results of its operation are not known. Deposits, also of doubtful value, are reported near Rylstone and Bingara.

New Zealand.—Quicksilver minerals have been found in regions of recent volcanic activity in New Zealand, but no deposits of economic value are known, and the Government is understood to have offered a bonus of 8 cents a pound for the first 100,000 pounds retorted from domestic ore. Prospecting is said to have been in progress in 1917 at Puhi Puhi, on North Island, with encouraging results.

New Caledonia.—Some occurrences of cinnabar have been reported in New Caledonia, but none, so far as known, is worked or is of economic value.

AFRICA.

Occurrences of cinnabar have been reported from the Transvaal, Abyssinia, and Madagascar, but only in Algeria have deposits been worked. These, according to De Launay,[2] occur as complex veins that carry, besides cinnabar, galena, tetrahedrite, sphalerite and stibnite. Deposits of the same general character occur in Tunis.

NORTH AMERICA.

In North America the quicksilver deposits are confined to the Cordilleran region from Alaska to Central America. By far the most productive deposits are in California and western Texas.

Alaska.—In Alaska minerals containing quicksilver have been found in the sluice boxes in a number of the placer-mining districts, but deposits in place have been discovered in the central Kuskokwim region only.[3] At the Parks prospect, 15 miles upstream from Georgetown, the ore occurs as cinnabar accompanied by stibnite, quartz, and a ferruginous dolomite in shattered Cretaceous shale in association with intrusive bodies of diabasic and granitic rock.[4] Development has been hindered by the difficulties of access to the region, and only a few hundred pounds of quicksilver has been produced for local consumption. Another prospect is 5 miles below Kolmakof and about 100 miles downstream from the Parks prospect.[5] Here quartz lenses and veinlets containing cinnabar occur in arkosic sandstone, closely associated with a sill of altered "andesite."

---

[1] Ball, L. C., Mercury in Queensland: Government Min. Jour., vol. 15, pp. 623–629, 1914. Dunstan, B., Queensland mineral deposits, 11. Mercury: Idem, vol. 18, pp. 232–238, 1917.

[2] Launay, L. de, Gîtes minéraux et métallières, vol. 3, p. 445, Paris, 1913.

[3] Smith, P. S., and Maddren, A. G., Quicksilver deposits of the Kuskokwim region: U. S. Geol. Survey Bull. 622, p. 272, 1915.

[4] Smith, P. S., The Lake Clark-Central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, 1917.

[5] Smith, P. S., and Maddren, A. G., op. cit., p. 272.

Quicksilver ore in place is reported also on the divide between Kuskokwim and George rivers, about 2½ miles northwest of the Parks prospect, and near Iditarod.[1]

Canada.—A small output of quicksilver was recorded in Canada in 1895–1897 from pockety deposits of cinnabar in quartz veins cutting Tertiary volcanic rocks near the west end of Kamloops Lake, British Columbia. Cinnabar and native quicksilver are reported to occur on Groundhog River near the Transcontinental Railroad,[2] but, so far as known, these deposits have never been developed. Some cinnabar, but not in commercial quantity, has been stated to occur in the silver ore of the Nipissing mine of the Cobalt district.

Washington.—In Washington quicksilver ores have been prospected near Orondo, in Chelan County; north of Cle Elum, in Kittitas County; and near Morton, in Lewis County. The production from this State is thus far inconsiderable.

Oregon.—In Oregon there are many widely distributed occurrences of cinnabar, but only one deposit, that at Blackbutte, in Lane County, is at present productive, although occasionally a flask or two is obtained from prospects near Gold Hill, in the southwestern part of the State.[3]

The principal ore body of the Black Butte mine is a metallized fissure zone in andesite. It is about 200 feet long, up to 15 feet wide, and has been worked to a depth of about 400 feet. The ore body has been cut on the 500-foot level, but on the only level below this, the 900-foot, no workable body of ore has yet been found. The ore averages about 0.2 per cent of quicksilver, and the quantity available above the 500-foot level is estimated by the company at about 150,000 tons.

California.—It is not possible in an outline of this brevity to describe all of the deposits in California. Only a few notes can be given on those that are now leading producers or are likely in the near future to attain that rank. Many of the most productive mines of the past—as, for example, the Redington, or Knoxville, Great Western, and Oat Hill—have yielded no quicksilver from underground work for many years.

The most productive mine in California at present is the New Idria, in San Benito County, which in 1917 yielded 11,000 flasks out of a total for the State of 23,938 flasks and for the United States of 36,159 flasks. The New Idria ore comes from two mines, the New Idria proper and the San Carlos, which lies about 1¾ miles southeast of the New Idria. The New Idria has been extensively opened to a depth of about 1,000 feet. The San Carlos is worked principally by open pits, although a level, now abandoned, was run at a depth of 500 feet.

The New Idria ore bodies occur as rudely lenticular or pipelike masses in steeply upturned Franciscan sandstone and shale, the shale being generally indurated and closely laminated with thin layers of sandstone. The San Carlos ore forms very irregular masses in similar but in general somewhat softer sandstone and shale of the Franciscan, and, to a less extent, in soft crushed serpentine. The two mines contributed nearly equally to the total production in 1917, and the average won tenor of the ore in that year was 0.32 per cent.

---

[1] Smith, P. S., and Maddren, A. G., op. cit., pp. 286–287.

[2] Report from U. S. Consul H. D. Dill, Orillia, Ontario, Dec. 12, 1911.

[3] Since this report was written the Rainier mine, in the Meadows district, near Gold Hill, has become productive.—F. L. R.

The New Almaden mine, situated in Santa Clara County, 12 miles south of San Jose, comprises an extensive system of underground workings to a depth of 2,245 feet. At present, however, all the levels below the 800 foot are under water, and of late years very little ore has been taken from the old mine. Most of the recent production of the New Almaden Co. (Inc.) has come from the Senator (El Senador) mine, about 3 miles northwest of the old mine, and from quicksilver recovered from ground under old furnaces and condensers.

In the New Almaden, in the Senator, and in the neighboring New Guadalupe the ore occurs as irregular, more or less lenticular masses in opalized and otherwise altered serpentine. In 1917 the New Guadalupe ore averaged very nearly 1.1 per cent in won tenor. Close to the mine now being operated by the New Guadalupe Mining Co., and owned by the same company, is the original Guadalupe mine, once highly productive but which has long lain idle. It has recently been pumped out and may soon yield additional quicksilver. The ground both of the New Almaden and New Guadalupe companies has great possibilities, but no estimate can be made at present of the quantity of ore probably available.

The Oceanic mine, situated 4 miles east of Cambria, in San Luis Obispo County, ranked fourth in production in California in 1917. The ore occurs as an impregnation of nearly vertical, fine-grained Tertiary, probably Miocene, sandstone. The ore body is about 600 feet long, 40 feet wide at the surface, and has been worked from the surface to the 300-foot level, where it is said to be about 15 feet wide. The so-called 300-foot level, now under water, is about 555 feet below the highest point at which ore was mined at the surface and 300 feet below the fourth (tunnel) level. Most of the ore at present is coming from ground above the fourth level, which is 255 feet below the highest surface ore. The average won tenor of the ore in 1917 was 0.185 per cent.

Other mines in California which yielded from 500 to 1,000 flasks in 1917 are the Great Eastern, near Guerneville; the Cloverdale, about 8 miles east of Cloverdale; and the Culver-Baer, about 12 miles (20 miles by road) east of the same town, all in Sonoma County. Those whose output was between 400 and 500 flasks are the St. Johns, near Vallejo, Solano County, and the Helen, near Middletown, in Lake County.

Nevada.—The principal mines in Nevada have already been mentioned on page 389. The total yield from this State in 1917 was 997 flasks, nearly half of which came from the Farnham and Drew mine, east of Mina, which closed for lack of ore near the end of the year. The next mine in point of yield, the Goldbanks, is also at present nonproductive.

Idaho.—Only nominal production has been reported from Idaho, but the Fern mine near Yellow Pine, Valley County, is being developed with promising results. The ore occurs as replacement deposits in limestone which is interbedded with quartzite. There are also some prospects in Cassia County, near Black Pine.

Montana.—There is an undeveloped deposit of cinnabar near Boulder.

Utah.—Quicksilver was formerly produced as a by-product from cinnabar associated with gold ores of the Mercur district, and from the unusual sulphoselenide ores of mercury near Marysvale.

Arizona.—The deposits of quicksilver ore known in Arizona are at present of so little economic importance that it appears unnecessary in the present brief sketch to describe individual occurrences.

Texas.—The principal mines in the Terlingua district are the Chisos, Mariposa, Big Bend, and Dallas. These all lie nearly on an east-west line, 11 miles long. Another producing mine, the Ellis, is situated about 35 miles east-southeast of Terlingua post office and 6 miles south-southwest of McKinney Springs post office, between the Chisos Mountains and the Rio Grande. The largest and most productive mine is the Chisos, which is opened by three shafts to a depth of 750 feet along a metallized fault zone for a length of about 2,000 feet. The principal source of quicksilver in the ore now mined is cinnabar, but the district is noted for the rare oxychlorides and other secondary mercury minerals formerly abundant in shallow workings. Some of these, so far as known, occur only in this district.

Mexico.—Deposits containing quicksilver are rather widely distributed through Mexico but are not at present very productive, and information concerning the state of the quicksilver-mining industry is difficult to obtain in the existing disturbed condition of the country. The most productive mines are in the State of San Luis Potosi, particularly near Moctezuma, 40 miles north of the city of San Luis Potosi and near Guadalcazar, about 60 miles northeast of the same place. At Guadalcazar the deposits, which prior to the political upheaval in Mexico were yielding from 500 to 700 flasks a year, occur in Cretaceous limestone near porphyry. The principal mines are the Nuevo Potosi and Trinidad. The ores are described as consisting of metacinnabar (guadalcazarite) and cinnabar, with calcite, fluorite, gypsum, and native sulphur.[1]

The ores at Moctezuma are reported to be of fairly high grade and similar in general character to those of the longer-known Guadalcazar district. The output in 1912 was reported to be about 1,200 flasks a year.

The mines near Huitzuco, in the State of Guerrero, have been worked since 1873. The ore occurs as irregular pipelike bodies at enlargements of fissures in middle Cretaceous limestone. These bodies are described by Villarello[2] as from 50 to 80 meters in diameter and up to 250 meters, or possibly more, in depth. The ores consist of livingstonite, pyrite, and free sulphur, with much gypsum and calcite. Occasionally some metacinnabar is found. According to Halse[3] the main shaft of the Santa Cruz mine went through 144 feet of gypsum and did not enter wholly unaltered limestone until it attained a depth of 380 feet.

---

[1] Halse, Edward. Quicksilver mines and reduction works at Huitzuco, Guerrero, Mexico: Fed. Inst. Min. Eng. Trans., vol. 10, pp. 72–88, 1895–1896. Contains notes on Guadalcazar mines.

Rundall, W. H., Mining and treatment of quicksilver ores at Guadalcazar, Mexico: Eng. and Min. Jour., vol. 59, pp. 607–1895.

Mexican quicksilver mining operations: Min. and Eng. World, vol. 37, p. 282, 1912. [Extract from consular report.]

[2] Villarello, J. D., Génesis de los yacimientos de Palomas y Huitzuco en los estados de Durango y Guerrero de la República Mexicana: Soc. cient. "Ant. Alzate" Mem. y. rev., vol. 19, pp. 95–136, 1903.

[3] Halse, Edward, op. cit.

The principal mines at Huitzuco are understood to have belonged to the wife of former President Diaz. Although it is learned that they have not been regularly worked since his overthrow, considerable quantities of mercury are reported to have been brought from Huitzuco to the City of Mexico. This was probably obtained from working the old dumps. A new company, the Cía. minera de Cinabrio, with offices in the city of Mexico, is reported as about to work the Las Negrillas mine, near Huitzuco, with the expectation of producing about 300 flasks a month.

There are at least three quicksilver mines in the State of Zacatecas that have yielded quicksilver, the San Antonio at Ville Garcia, the San Carlos in the municipality of Carro, and the El Puesto at El Puesto. The San Antonio is reported to be well equipped and to be making a small production under the present control of revolutionists. Quicksilver is also recovered in this State near Fresnillo as secondary metal from old patios in which silver ores have been treated by amalgamation.

Quicksilver deposits occur at Palomas, 80 kilometers west of the city of Durango, in the State of that name. They are described by Villarello[1] as irregular, nonpersistent veins in altered rhyolite near intrusive basalt. Cinnabar, a little native quicksilver, and a bituminous mineral are associated with "amorphous silica" (opal?) as gangue. The mean tenor of the ore formerly worked is given as 0.5 per cent.

Occurrences of mercury minerals are known also in the States of Chihuahua, Sonora, Tepic, Jalisco. At San Onofre, in Jalisco, is the type locality of the sulphoselenide of mercury onofrite. Some of the deposits in Chihuahua are understood to belong to the same general group as those in trans-Pecos Texas, but no definite information relating to them has been obtained.

Formerly most of the quicksilver obtained in Mexico was consumed in that country or exported to London. Recently, however, considerable quantities have been sent to the United States.

Central America.—Cinnabar has been reported as occurring in Guatemala, and native quicksilver is found in clay on the Isthmus of Panama.

SOUTH AMERICA.

In South America quicksilver deposits are known in British Guiana, Colombia, Ecuador, Bolivia, Chile, Brazil, Argentina, and Peru, and reported also in Uruguay, Venezuela, and Paraguay. Only those in Peru and Chile appear to be of present economic importance, and the production of Peru in 1916 was only 62 flasks (2.1 metric tons).

The most famous deposits in Peru are those at Huancavelica,[2] particularly those of the Santa Barbara mine. These have been worked since 1566 and are said to have produced 46,500 metric tons (1,366,480 flasks of 75 pounds) before 1790. The production in the nineteenth century has been estimated at 3,500 metric tons (102,865 flasks).

---

[1] Villarello, J. D., op. cit.

[2] Umlauff, A. F., El cinabrio de Huancavelica: Cuerpo Ing. Minas del Perú Bol. 7, 1904.

The ore bodies of the Santa Barbara mine occur on the east flank of the western chain of the Andes in a steeply upturned series of Cretaceous limestones, shales, and sandstones and post-Cretaceous conglomerates. These rocks are cut by andesite and basalt. The ore zone runs north-northwest and has a length of about 50 kilometers. The ore bodies are numerous, irregular, and occur in all of the stratified rocks mentioned, particularly in the sandstone and limestone. The ore is reported to have had a tenor of 2 per cent or more of quicksilver and to have continued to a depth of 190 meters.

In 1915 the greater part of the quicksilver-bearing ground in the Huancavelica district was purchased by Eulogio E. Fernandini, of Lima, and work has already been begun preparatory to a resumption of mining on an extensive scale. The old main tunnel of the Santa Barbara mine had been reopened by the end of 1916 for about 1,150 feet and a new tunnel had been begun about 500 feet below the old tunnel. There was also under construction in that year a hydroelectric plant to supply power to the mine.[1]

At Yauli, in an Andean valley about 120 kilometers east-northeast of Lima, cinnabar and pyrite occur in quartz veins in shales and sandstone in the vicinity of hot sulphur springs.

In Chile, at Punitaqui, in the Province of Coquimbo, quicksilver ores occur in irregular veins closely associated with gold veins and veins carrying copper and tin. The prevailing rocks of the region are syenite and diorite, which are cut and locally metamorphosed by a broad intrusive mass of diabase, in which the quicksilver deposits occur. The quicksilver ores consist of cinnabar, pyrite, chalcopyrite, hematite, chalcocite, and mercurial tetrahedrite in a quartz gangue.[2] These ores, carrying more than 0.4 per cent of quicksilver, were being retorted in 1916[3] and probably in 1917, although there is no official record of any production of mercury in Chile in 1916, the latest year for which figures are available.

In the same province, near Arqueros, the occurrence of native silver amalgam has long been known[4] and the same mineral is found near Rosilla, in the Province of Atacama. Deposits of sulphide of mercury, presumably cinnabar, are also reported near Petorca, in the Province of Aconcagua.[5]

QUICKSILVER-MINING INDUSTRY BY STATES.

ALASKA.

So far as known, there was no production of quicksilver in Alaska in 1917 and no important activity to record.

ARIZONA.

Arizona produced only 40 flasks in 1917, of which 38 flasks came from the Sunflower district in the Mazatzal Range and 2 flasks from the southern part of the Phoenix Mountains, 9 miles northeast of

---

[1] Cuerpo Ing. Minas del Perú Bol. 86, p. 127, 1918.

[2] Götting, A., Die Erzgänge zu Punitaqui in Chile, mit besonderer Berüchtsichtigung der Zinnoberführenden Lagerstätten: Zeitschr. prakt. Geologie, 1894, pp. 224–230.

[3] Lamb, M. R., Flotation for cinnabar: Min. and Sci. Press, vol. 113, p. 6, 1916.

[4] Domeyko, Ignace, Sur les mines d'amalgame natif d'argent d'Aqueros, au Chili: Annales des mines, vol. 20, pp. 255–307, 1841.

[5] Ortúzar, Adolfo, Chile of to-day, New York, 1907.

Phoenix. The total production from this State to date has been extremely small, and since 1914, when the furnace of the Cinnabar Development Co., near Quartzsite, Yuma County, was shut down, it has come chiefly from small lots of ore retorted in connection with prospecting.

GILA AND MARICOPA COUNTIES.

In the Mazatzal Range,[1] on both sides of the boundary between Maricopa and Gila counties, prospecting and development has been in operation on a small scale since 1912. In 1917 the claims of the Sunflower Cinnabar Mining Co. were worked for a time under lease to C. N. and M. A. Sears, and the bank of retorts was rebuilt.

Prospecting was in progress in the Phoenix Mountains, Maricopa County, on deposits described by F. C. Schrader[2] as shear zones in schist, carrying cinnabar, metacinnabar, and a little native quicksilver, with quartz, calcite, and iron oxide, the last presumably from pyrite or marcasite. The principal lodes, 3 in number, strike northeast to north-northeast, and the most extensive development work at the close of the year was a shaft 70 feet deep. The deposits are similar in character to those in the Mazatzal Range and have the advantage of greater accessibility.

PIMA COUNTY.

At the Roadside mine in Pima County, Courtney De Kalb, consulting engineer, reported to the Survey in 1915 the presence of cinnabar, native mercury, and mercurial tetrahedrite in copper-silver ore. So far as known, there has been no production of quicksilver from this locality, and the occurrence, like the similar ores described by Lindgren[3] in the Blue Mountains of Oregon, appears to be of scientific rather than economic interest.

YAVAPAI COUNTY.

In Skull Valley, in Yavapai County, the occurrence of cinnabar has long been known[4] and has led to some shallow prospecting. The cinnabar is reported to be associated with quartz in a vein in granite. There appears to have been no activity at this locality in 1917.

YUMA COUNTY.

The mine of the Cinnabar Development Co., near Quartzsite, remained closed.

CALIFORNIA.

PRODUCTION.

Quicksilver mining was actively prosecuted in California in 1917 and yielded 23,938 flasks, valued at $2,521,151. Of this 21,780 flasks was reduced in furnaces, 1,823 flasks in retorts, and 335 flasks was recovered by washing. The output in 1916 was 21,045 flasks, valued at $2,649,355. There was therefore in 1917 a gain of 13.7 per cent in quantity but a loss of 4.8 per cent in value. The output of the State for 1917 was the largest since 1905 and, next to 1916, the record year for high average price, was the greatest in value since 1877. It constituted 66 per cent of the total quicksilver output of the country.

---

[1] Ransome, F. L., Quicksilver deposits of the Mazatzal Range, Ariz.: U. S. Geol. Survey Bull. 620, pp. 111–128, 1915.

[2] Schrader, F. C., Quicksilver deposits of the Phoenix Mountains, Ariz.: U. S. Geol. Survey Bull. 690–D, pp. 95–109, 1918.

[3] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, p. 664, 1902.

[4] Blake, W. P., Minerals of Arizona, their occurrence and association; a report to the governor of Arizona, p. 15, Tucson, 1909.

In the following table, which gives the annual yield of quicksilver in California from 1850, when production began, to date, the quantities are recorded in flasks of 76½ pounds to June, 1904, since when they are given as the present standard domestic flasks of 75 pounds.

Quicksilver produced in California, 1850–1917.

Year.	Flasks.	Price per flask.	Value.	Year.	Flasks.	Price per flask.	Value.
1850	7,723	$99.45	$768,052	1885	32,073	$30.75	$986,245
1851	27,779	66.93	1,859,248	1886	29,981	35.50	1,064,325
1852	20,000	58.33	1,166,600	1887	33,760	42.375	1,430,580
1853	22,284	55.45	1,235,648	1888	33,250	42.50	1,370,625
1854	30,004	55.45	1,663,722	1889	26,464	45.00	1,190,880
1855	33,000	53.55	1,767,150	1890	22,926	52.50	1,203,615
1856	30,000	51.65	1,549,500	1891	22,904	45.25	1,036,406
1857	28,204	48.73	1,374,381	1892	27,993	40.71	1,139,595
1858	31,000	47.83	1,482,730	1893	30,164	36.75	1,108,527
1859	13,000	63.13	820,690	1894	30,416	30.70	933,771
1860	10,000	53.55	535,500	1895	36,067	37.04	1,335,922
1861	35,000	42.05	1,471,750	1896	30,765	34.96	1,075,544
1862	42,000	36.35	1,526,700	1897	26,691	37.28	995,040
1863	40,531	42.08	1,705,544	1898	31,092	38.23	1,188,647
1864	47,489	45.90	2,179,745	1899	29,454	47.70	1,404,956
1865	53,000	45.90	2,432,700	1900	26,317	44.94	1,182,686
1866	46,550	53.13	2,473,202	1901	26,720	48.46	1,294,851
1867	47,000	45.90	2,157,300	1902	28,972	43.20	1,251,590
1868	47,728	45.90	2,190,715	1903	30,526	45.29	1,382,523
1869	33,811	45.90	1,551,925	1904	29,217	43.50	1,270,940
1870	30,077	57.38	1,725,818	1905	24,635	36.22	892,280
1871	31,686	63.10	1,999,387	1906	20,310	39.50	802,245
1872	31,621	65.93	2,084,773	1907	17,431	39.60	690,268
1873	27,642	80.33	2,220,482	1908	16,984	44.17	750,183
1874	27,756	105.18	2,919,376	1909	16,078	45.45	730,745
1875	50,250	84.15	4,228,538	1910	17,211	46.51	800,484
1876	72,716	44.00	3,199,504	1911	18,860	46.01	867,749
1877	79,395	37.30	2,961,434	1912	20,524	42.05	863,034
1878	63,880	32.90	2,101,652	1913	15,591	40.23	627,228
1879	73,684	29.85	2,199,467	1914	11,303	49.05	554,414
1880	59,926	31.00	1,857,706	1915	14,283	85.80	1,225,481
1881	60,851	29.83	1,815,185	1916	21,045	125.89	2,649,355
1882	52,682	28.23	1,487,213	1917	23,938	105.32	2,521,151
1883	46,725	28.75	1,343,344				
1884	31,913	30.50	973,347		2,210,852	....	102,851,913

As usual, San Benito County, in which are situated the New Idria workings, at present the most productive mine in the Western Hemisphere, leads, with nearly half of the total output of the State. It is followed by Santa Clara County, which contains the New Almaden, the largest, deepest, and in total output, the most productive quicksilver mine in California, and the New Guadalupe mine. Third in rank is Sonoma County, with the Cloverdale, Great Eastern, Culver-Baer, and Socrates mines. San Luis Obispo County, in which the Oceanic was the leading mine in 1917, comes fourth, and Lake County, with the Helen, Sulphur Bank, and Big Injun as chief producers but with a number of famous old mines now idle, ranks fifth. Napa County, also containing many old mines that contributed largely to the production of the State in past years, now holds sixth place.

Thirty-four operators reported production in California in 1917. Of these, two, the New Almaden Co. (Inc.) and the New Idria Quicksilver Mining Co., were each conducting productive operations at two distinct mines at adjacent localities under one management. At 17 localities the metal was obtained by furnace reduction from mines having considerable development, although at only four of them was the ore hoisted by machinery. At 12 localities it was won by retorts from mines generally but not invariably less developed than those equipped with furnaces. At six localities it was recovered entirely from salvage operations on old dumps or reduction works, usually by gravity concentration and retorting, and at one locality by steam-shovel work on old dumps, followed by gravity concentration and retorting. Altogether, there was mined or handled about 248,000 tons of ore, of which 235,786 tons was treated. About 20,000 tons of this material was moved with a steam shovel at Sulphur Bank, which marks a new departure in quicksilver mining in California. Of the ore treated, 223,069 tons was sent through furnaces and 4,931 tons of new ore and dump concentrates was retorted. At New Almaden 335 flasks of quicksilver was recovered by passing through a washer 7,786 tons of material excavated from the sites of old furnaces.

Quicksilver produced in California, 1917, by counties.

County.	Quantity (flasks of 75 pounds).	Value.	County.	Quantity (flasks of 75 pounds).	Value.
Lake	1,159	$122,066	Solano	515	$54,240
Napa	832	87,626	Sonoma	2,538	267,302
San Benito	11,018	1,160,416	Others [a]	727	76,568
San Luis Obispo	1,366	143,867			
Santa Clara	5,783	609,066		23,938	2,521,151

[a] Includes Colusa, Fresno, Kern, Monterey, Trinity, and Yolo counties, in each of which there was only a single mine productive.

COLUSA COUNTY.

The Manzanita mine, near Wilbur Springs, in the Sulphur Creek district, which has been worked for both gold and quicksilver, was under lease and bond in 1917 to the Cerise Gold Mining Co., but this company's operations were confined to a gold deposit on Cerise Hill a short distance south of the old Manzanita workings and on the opposite side of Sulphur Creek. A little prospecting was done at the old Elgin mine and a few flasks of quicksilver obtained by retorting samples. The Wilbur Hill, Central, Empire, and Wide Awake mines remained idle.

FRESNO COUNTY.

Work at the Mercy mine was resumed in July, but after a three-months' run, during which a small production was made, the furnace was cooled for repairs.

KERN COUNTY.

The Cuddeback mine, situated about half a mile northeast of Tehachapi Loop on the Southern Pacific Railroad, near Keene, was productive during the year, the ore being treated in 12 Johnson-McKay retorts.

The deposit in which this mine has been developed is noteworthy as lying outside of the generally recognized quicksilver belt of California and as being, unlike most bodies of quicksilver ore in that State, of recent discovery. In character, also, it is different from all others in the State. The general rock of the vicinity, a rather dark medium-grained granite or granodiorite is cut by a number of rhyolite dikes, of which at least two contain cinnabar. The dike of the Cuddeback mine is about 100 feet wide and at least 500 feet long. It shows nearly vertical, but curved and contorted lamination, and is all more or less altered. The known ore bodies, of irregular form, occur in the dike, near small fissures that are generally nearly parallel with the dike walls. The typical ore is rather soft, altered, chalky rhyolite, colored pink by finely disseminated cinnabar. Cinnabar is stated[1] also to occur as veinlets or seams an eighth of an inch in thickness. The deepest workings, early in 1918, were probably not more than 30 feet below the surface, and ore had been mined at three places within a length of about 500 feet.

KINGS COUNTY.

The Kings Quicksilver Mining Co., working on the Segregation claim, made a very small production in January, with a 20-ton Scott furnace. The mine was closed, however, on February 1, and remained idle for the rest of the year.

LAKE COUNTY.

The Helen, at present the most productive mine in Lake County, was operated successfully throughout the year. During the latter part of 1917 the ore was obtained chiefly from the northwestern part of the mine—in the Santa Maria workings, on the Helen claim—and contained so much pyrite as to cause considerable difficulty in its treatment. The product of the 50-ton Scott furnace was obtained as soot, which necessitated the interruption of furnace operation for periodic clean-ups. The Wall Street mine is about half a mile down the canyon from the Helen, on the road to Middletown, on a lode in serpentine, which is thought by some to be a faulted portion of the Helen lode. There does not appear to be a particle of evidence, however, for this supposed relationship. As usual, the mine, which has a depth of about 90 feet, was worked by the owner unaided and he made a small production from a D retort and a small ingeniously constructed furnace. The Chicago mine, near the Helen, equipped with an unfinished 15-ton Scott furnace of reinforced concrete, remained idle. The Big Injun mine, about 2 miles northwest of the Helen, was active for part of the year and produced some quicksilver with a concentrating table and retorts. About the end of the year ore was discovered at the surface about 1 mile northeast of the Big Injun and half a mile south of Anderson Springs. At the date of writing considerable production has already been made from this deposit, now known as the Big Chief. The ore, which, as seen in the initial surface cut, consists of innumerable little stringers of cinnabar in radiolarian chert, has been treated in the Big Injun retorts.

---

[1] Gillan, S. L., Cinnabar in the Sierra Nevada: Min. and Sci. Press, vol. 114, p. 79, 1917.

Probably the most interesting development in Lake County during the year was the resumption in June of work on an extensive scale at the famous old Sulphur Bank mine. Here the rock of widespread dumps, estimated to contain at least 800,000 tons of material, consisting chiefly of basalt that has been leached of practically all of its constituents save silica and contains cinnabar and free sulphur, was being handled with a steam shovel, crushed, and subjected to gravity concentration in a 125-ton mill equipped with 4 Deister-Overstrom tables and 2 Risdon-Johnson vanners. The concentrates were being resorted in two benches of twelve 12-inch Johnson-McKay retorts and 4 small D retorts. One or more rotary furnaces have since been added, and concentration will probably be abandoned. The mine is operated under lease by the Sulphur Bank Association and is likely during 1918 to become one of the large producers of the State.

The Mirabel and Great Western mines near Middletown were idle in 1917, with no prospect of a resumption of activity. The Baker mine, 3 miles southeast of Lower Lake, was worked and made a small production from 7 pipe retorts. An inclined shaft was sunk on the vein to a depth of 100 feet. At the Abbott mine, near Wilbur Springs, the 50-ton Scott furnace was operated for a month, and some quicksilver was produced. The mine was idle, however, at the end of the year.

MONTEREY COUNTY.

The Patriquin, near Parkfield, the only productive quicksilver mine in Monterey County, was worked steadily and yielded considerable quicksilver from two benches of 12 pipe retorts, with a total capacity of about 3 tons in 24 hours. The ore occurs in altered serpentine and is mined by very irregular workings to a depth of about 160 feet. No attempt is made to handle rock containing less than 1 per cent of quicksilver, and there has been no systematic underground exploration or development.

NAPA COUNTY.

The old Oat Hill mine, which was worked by the Napa Consolidated Mining Co. from 1867 to 1909 and was one of the larger and more productive mines in the State, was acquired in 1917 under a 20-year lease and bond by Mr. Murray Innes, who immediately began reopening some of the old tunnels and prospecting new ground. The ore in this mine occurs in sandstone[1] of the Franciscan group in the immediate vicinity of six or more persistent fissures that strike from west-northwest to north-northwest. A small production was made from the Oat Hill dumps by concentration and retorting. The Knoxville, also known as the Boston and formerly as the Redington, one of the best-known and most productive quicksilver mines in California, remained idle in 1917, although a little metal was retorted from dumps and old furnaces. The Manhattan mine was also unworked.

---

[1] In Becker's well-known monograph on the geology of the quicksilver deposits of the Pacific slope (U. S. Geol. Survey Mon. 13, 1888) the sandstone in the vicinity of the mine is described as covered by a thin sheet of basalt which is represented on the geologic map of Oat Hill by H. W. Turner, published as Plate V of that report. This sheet does not exist, although the surface of the sandstone slopes is littered with loose blocks of basalt that, during the progress of erosion, have rolled or crept down hill from a thick flow of basalt, a remnant of which caps the hill north and west of the mine openings. This flow is the "thick sheet" shown on the edge of the map just mentioned.

At the Aetna mine, 12 miles north of St. Helena and about 3 miles southeast of Oat Hill, work was in progress during the second half of the year. Some new buildings were constructed, additional machinery was put in, and the mine was reopened. Production was begun with a 45-ton Scott furnace. At the Twin Peaks mine, between Aetna Springs and Oat Hill, prospecting was in progress on a small scale, but no quicksilver was produced. The Corona mine, between the Twin Peaks and the Oat Hill mines, was idle in 1917. No production was made by the Belle Union mine, near Oakville. The La Joya mine, about 4 miles west of Oakville, was in operation during the year, and yielded considerable quicksilver. The mine is equipped with an old Fitzgerald furnace, with a capacity of about 8 tons, a Livingston patent retort furnace that has not been successfully operated, and 12 Johnson-McKay retorts.

SAN BENITO COUNTY.

As usual, the New Idria and the jointly operated San Carlos mine yielded most of the quicksilver produced in the county, about half of the total quantity coming from each mine. Owing largely to the difficulty of securing trained miners a large part of the ore was obtained by surface and open-cut work.

The ore from the San Carlos is brought to the mill and furnaces at Idria over a Painter aerial tramway 10,000 feet in length, and a similar tramway, 3,500 feet long, to carry ore from above the fifth level of the New Idria mine, was completed at the end of the year. The San Carlos tramway in 1917 was transporting 240 tons a day, but twice this quantity could easily be carried. There were in operation near the end of the year a 200-ton gravity concentrating mill, which was reducing the excess of fine ore to a 12 per cent concentrate, two 88-ton coarse-ore furnaces, and a 60-ton fine-ore Scott furnace. There was under construction a 48-inch by 50-foot rotary furnace with cylindrical redwood-tank condensers, and similar condensers were being gradually substituted for the old brick condensers at the other furnaces. According to the company's published report, the ore treated was a little higher in grade than in 1916.

The Aurora mine, situated a short distance southeast of the New Idria, made an exceedingly small production and was practically idle for most of the year. No production was made by the Alpine, Florence Mac, Hernandez, or Wonder mines, although some prospecting was done at the Alpine.

SAN BERNARDINO COUNTY.

Cinnabar is reported to occur in dikes from 10 to 100 feet in width, near Danby. Shallow prospecting was in progress at the end of the year.

SAN LUIS OBISPO COUNTY.

The Oceanic mine, 5 miles east of Cambria, was by far the most productive mine in the county, although the ore is probably the lowest in grade that is worked in California. It was also the only quicksilver mine in operation in the county at the end of 1917. The concentration mill, built at the Oceanic by former lessees, has been abandoned and dismantled by the owner, and all of the ore is now treated in two 50-ton Scott furnaces. The Klau or Karl mine produced some quicksilver early in the year with 2 banks of 12-pipe retorts. No use has been made of the 50-ton Scott furnace since the building inclosing it was destroyed by fire. A small quantity of quicksilver was obtained from the Little Bonanza or Josephine mine. The Huasna mine (Deer Trail claim), situated in Stevens Canyon, 6½ miles east-southeast of Huasna post office, made a small production with 12-pipe retorts from a bunch of good ore in serpentine. At the end of the year no work whatever was in progress at the Klau, Little Bonanza, Belt (Libertad), or Cambria mines.

SANTA BARBARA COUNTY.

In the El Montecito mining district, on Santa Ynez River, north of Santa Barbara, a very small production was made, with retorts, from claims on the Los Prietos lode. The lode has not been examined by any geologist of this Survey, but from all accounts appears to be a persistent and regular zone of metallization between serpentine on the south and sandstone and conglomerate on the north. The deposit is evidently not suited to retort reduction, but might be successfully worked with a furnace. There are five or six groups of claims in the district and three sets of retorts. Work in 1917 was confined chiefly to development and to building roads and trails.

SANTA CLARA COUNTY.

At New Almaden the principal output was from the El Senador or Senator mine, about 4 miles northwest of the famous old workings in Mine Hill. The El Senador ore was reduced in a 45-ton Herreshoff furnace fitted with a Cottrell treater. A 90-ton Scott furnace, however, was under construction, and in June, 1918, use of the older furnace was discontinued, although it is said to have worked fairly well, giving an extraction of about 82 per cent. The ore at the El Senador occurs as lenticular bunches of irregular stringers of cinnabar in altered serpentine, generally near the contact of this rock with sandstone of the Franciscan group. There is much crushing and shearing, and the structure is complex in detail. A notable feature of the ore is the presence of fairly abundant stibnite in fine needles, a mineral not hitherto reported from the quicksilver deposits of Santa Clara County. During the year a new winze was sunk to the 600-foot level and the level was considerably extended.

Some underground work was done in Mine Hill through the Day tunnel (800-foot level), but this had been discontinued at the time of visit, early in 1918. At the old hacienda one small coarse-ore furnace was in operation on miscellaneous lots of ore, but the principal source of quicksilver was material from the site of old furnaces and condensers. The large boulders are picked out and the rest of the material is passed through a revolving screen, whose main function is to loosen the lumps of clay and soil. Oversize and undersize go into the same flume and are delivered to a log washer. Most of the quicksilver settles in the washer and is drawn off. From the washer the tailings go to a pulsating jig, which recovers additional quicksilver and some cinnabar. The jig tailings pass over riffles to the dump.

At the New Guadalupe, whose output of quicksilver was exceeded in California only by the New Idria, production, as in recent years, came from the newer mine on what is known as the Datum vein, a deposit similar in general character and relationships to that of the El Senador. This zone of metallization lies on the northeast side of Capitancillos Creek and runs northwest, or nearly parallel with the creek. The original zone of metallization on which the old Guadalupe mine was opened, lies southwest of the Datum and runs west-northwest, crossing the creek obliquely. In consequence of this fact, the old mine, which has been idle for years, made a great deal of water. The present company completed during the year a large concrete flume to carry off the creek water and early in 1918 had reopened the old mine to the fifth level and had begun to drive a connecting crosscut between the two mines. Some ore is reported to have been found in the course of this work.

There were in use in 1917 one of the two 15-ton coarse-ore furnaces and one of the two originally 24-ton Scott furnaces. All of the furnaces have been modified from their original design and differ from those used elsewhere. The ore, before going to the Scott furnace, passes through a rotary drier in which the temperature is high enough to volatilize some quicksilver, which is conducted into a condensing system common to all of the furnaces.

SISKIYOU COUNTY.

At the Ivanhoe mine near Cinnabar Springs, 10 miles northwest of Gottville, 12 Johnson-McKay retorts were operated for a short time on a few hundred pounds of ore collected in the course of earlier hydraulic washing and on material from prospect dumps, but very little quicksilver was obtained and none was shipped. The deposit consists of landslide material, mainly crushed schist, which is of very low grade as a whole but contains a few stringers of good ore in the schist fragments.

SOLANO COUNTY.

The St. Johns mine continued to make a good record in working low-grade ore, which occurs in dark soft shale, probably Knoxville, at or near the contact with very irregular bodies of light-colored much-altered intrusive rock whose original character has not yet been determined. The original irregularity of the intrusive bodies has been much increased by complex faulting. Close to the ore the shale is generally much harder than elsewhere. The two Neat coarse-ore furnaces were not in use in 1917, all the ore being treated in a Scott furnace with an actual capacity of from 18 to 25 tons. During the year the old brick condensers were replaced by cylindrical redwood tanks horizontally placed.

At the Hastings mine two of the three retorts were in use during the later part of the year, the Neat furnace being idle. The lessees of this mine have since ceased operations.

There appeared to be some possibility that the Brownlie mine between the St. Johns and the Hastings might be reopened.

SONOMA COUNTY.

The Great Eastern, Cloverdale, and Culver-Baer mines were considerable producers in 1917. The United States Mines Development Corporation, operating the Socrates mine, rebuilt the 40-ton Scott furnace, carried out other improvements at the mine, and produced some quicksilver. The company, however, became involved in legal difficulties in connection with the purchase of the property and ceased operations early in 1918.

The ore of the Socrates mine contains a larger proportion of native quicksilver than any other mine now worked in California unless possibly the small deposit at the Rattlesnake. It occurs generally in disturbed sandstone of the Franciscan close to serpentine, which forms the hanging wall.

An inconsiderable production was made by the Rattlesnake mine, which is worked on a small scale. The Eureka mine was idle.

The Great Eastern mine, near Guerneville, had a successful year, a body of good ore having been found in the upper workings. At the beginning of the year the mine was equipped with one 20-ton Scott furnace and one 14-ton Knox-Osborne coarse-ore furnace. The coarse-ore furnace proved unsatisfactory and was replaced by a new 20-ton Scott furnace.

The Cloverdale mine was steadily productive, although the old 25-ton Livermore furnace was evidently permitting considerable loss of quicksilver into the atmosphere. Early in 1918 the control of the Cloverdale mine passed into the hands of Andrew Rocca, well known in California for his long and successful experience in quicksilver mining. The title of the company, however, remains as the Western Mercury Co. The Cloverdale ore consists of cinnabar with a little pyrite or marcasite filling innumerable small fractures in shattered, brittle radiolarian chert of the Franciscan group.

The ore of the Culver-Baer mine was treated in a 14-ton coarse-ore Knox-Osborne furnace, the fine material being saved until enough accumulated to justify a run by the 24-ton Scott furnace. The ore bodies occur in a lodelike mass of ferruginous carbonate rock between walls of sandstone and shale of the Franciscan group. The lode material is altered serpentine.

STANISLAUS COUNTY.

A little development work but no production was reported at the Newhall mine, and there was no activity, so far as could be learned, in the Stayton district.

TRINITY COUNTY.

A very small production was made by lessees from the Altoona mine, near Castella.

YOLO COUNTY.

At the January mine, formerly known as the Harrison, considerable development work was carried out, buildings were constructed, machinery installed, a 100-ton gravity-concentration mill built, and four D retorts set up. A small production was made, but operations were limited by shortage of water. The ore occurs in dark opalized serpentine. At the Reed mine a small production was made from old dump material.

IDAHO.

A small production was reported from Idaho in 1917, from the Yellow Pine district in Valley County (formerly parts of Idaho and Boise counties). The following account of deposits in Cassia and Valley counties is based on notes supplied by E. S. Larsen, of this Survey, as the result of a visit made in August, 1918.

CASSIA COUNTY.

The claims of the Valentine Cinnabar Mining Co. are situated in the eastern part of Cassia County, on the eastern slope of the Black Pine Mountains and about 4 miles west of Black Pine post office, which is in Oneida County. The prevailing rock is limestone with some interbedded shale and sandstone. The general dip of the beds is west. No igneous rock occurs near the quicksilver deposit, so far as known.

The deposit, which appears to be parallel to the bedding of the sediments and to lie at the contact between a shaly bed and an overlying limestone layer, has the form of a chimney, lenticular in horizontal section, and only about 10 feet in length along the strike of the sediments. The friable vein material, which is a replacement of the limestone, is made up mostly of barite, with chalcedonic silica and some earthy cinnabar in thin films coating the barite. Small irregular bunches of ore show much more cinnabar than the mass as a whole.

Other prospects in the vicinity were not examined by Mr. Larsen.

VALLEY COUNTY.

In the Yellow Pine mining district, near the heads of Fern and Cinnabar creeks, and about 60 miles east by northeast of Cascade, active prospecting for quicksilver is being carried on by the Fern Quicksilver Mining Co., the Yellow Pine Quicksilver Co., the Monumental Mercury Mines Co. (the old Pringle-Smith prospect), and others. The deposits are in a series of sedimentary rocks made up of alternating limestones and quartzites that strike northwest and have a nearly vertical dip. These sediments have been invaded by a great granitic batholith, and only half a mile west of the prospects and about the same distance to the south the obliquely truncated sediments and the eroded surface of the granite are overlain by a considerable thickness of andesitic lavas. Dikes of quartz latite porphyry cut the sediments. The deposits are irregular replacements in the limestone layers, mostly near their contacts with the quartzites. The cinnabar is crystalline and is closely associated with veinlets of chalcedonic silica but is also present in the adjacent, iron-stained limestone; some pyrite (or marcasite), a very little stibnite, and some copper stains are associated with the cinnabar.

The Fern Quicksilver Mining Co. is working a stockwork of small stringers of chalcedonic silica, and its 12 Johnson-McKay retorts have been treating about 2 tons of ore a day. At the time of visit the retorts had been operated for about two weeks, and the average content of quicksilver won from the ore was a little over 2 per cent.

The principal workings of the Yellow Pine Quicksilver Co. are to the east of the Fern mine and at about the same stratigraphic horizon. Some cinnabar is shown in a few scattered prospect pits, but the main work is being done in a tunnel that is to crosscut a lenslike body of more or less silicified limestone which in outcrop is approximately 250 feet long and 60 feet wide and which shows some cinnabar in a few scattered pits. Below the outcrop the soil yields cinnabar on panning.

The workings of the Monumental Mercury Mines Co. are on Cinnabar Creek, about three-quarters of a mile north of the Fern mine and on a different layer of limestone. This limestone bed is about 150 feet thick, and the lower workings are near its southwest side, while the upper workings, which are about 1,500 feet to the northwest, are near the northeast side. The limestone exposed in the lower workings is brecciated and silicified and shows more or less cinnabar. The upper workings are planned to cut a similar body of silicified limestone about 60 feet by 100 feet on the outcrop. The company is operating 12 screw-top retorts with a capacity of about 14 pounds of ore each, and is preparing to install 52 such retorts, in which it plans to treat about 1 ton of picked ore a day and to operate throughout the winter of 1918–19.

MONTANA.

No quicksilver was produced in Montana in 1917, but a prospect owned by A. G. Lewis and partner about half a mile north of Boulder station, on the Great Northern Railway, and 100 yards from the railway track, was examined by E. S. Larsen. Mr. Larsen states that a coarse-grained granitic rock is traversed by several rudely parallel fissures along which chalcedonic silica has been deposited. A few shallow pits on one of these veins show earthy cinnabar coating fragments of fractured chalcedony, the whole being a foot or so wide.

NEVADA.

The production of quicksilver in Nevada in 1917 was 997 flasks, valued at $105,004, against 2,198 flasks, valued at $276,706, in 1916. Eight operators reported production in 1917, against 10 in 1916. The ore treated amounted to 3,639 tons, and yielded 20.4 pounds to the ton, or 1.02 per cent. The principal factors in bringing about the decreased production in this State were the destruction by fire of the furnace building of the Goldbanks Quicksilver Co. and the exhaustion of the single known ore body of the Nevada Cinnabar Co. near Ione. The Mercury Mining Co., also near Ione, made a much smaller output than in 1916, so that of the only three furnaces in the State one was wholly idle and the other two were operated for only a part of the year. One new deposit was discovered and developed during the year, that on Montgomery Mountain, in Esmeralda County.

Quicksilver produced in Nevada, 1903–1917.

Year.	Quantity (flasks).	Price per flask.	Value.	Year.	Quantity (flasks).	Price per flask.	Value.
1903	65	$45.29	$2,944	1912	2,550	$42.05	$107,228
1904	17	43.50	740	1913	1,645	40.23	66,178
1905	None.	36.22	....	1914	2,089	49.05	102,465
1906	None.	39.50	....	1915	2,827	85.80	199,657
1907	None.	39.60	....	1916	2,198	125.89	276,706
1908	None.	44.17	....	1917	997	105.32	106,004
1909	316	45.45	14,362				
1910	70	46.51	3,256		12,344	....	881,761
1911	70	46.01	3,221				

ELKO COUNTY.

The Ivanhoe Cinnabar Co., working at Ivanhoe Springs, about 50 miles in a straight line northwest of Elko and about 90 miles by road, produced a few flasks of quicksilver from shallow workings. The ore was treated in 6 D retorts with sagebrush as fuel. The ore is cinnabar which occurs as irregular stringers and as streaky disseminations in a much-altered, glassy rhyolite flow breccia. The most common kind of alteration is a change of the rhyolite to a cryptocrystalline white rock of flinty texture and splintery fracture. Some of it, however, has been converted to opal, some to fine-grained chalky material of as yet undetermined character, and some to a yellowish siliceous sponge. The cinnabar is widely distributed over an area of 5 or 6 square miles and much of the material is undoubtedly of very low grade, but some of the shallow cuts, particularly one on the Helen No. 1 claim, showed some excellent ore at the time of visit, late in 1917. The impression gained from such work as has been done is that the ore is all comparatively near the surface. Nothing was seen indicative of the persistence of workable deposits to a depth of over 50 feet, although the possible existence of deep ore can not be denied on the slender evidence afforded by the present stage of development. At least three groups of claims besides those of the Ivanhoe Cinnabar Co. were being prospected in 1917.

HUMBOLDT COUNTY.

The Goldbanks mine, 40 miles south of Winnemucca, was worked successfully from the 1st of June until July 10, when the building inclosing the 50-ton Herreshoff furnace was destroyed by a fire supposed to have been of incendiary origin. Prospecting and development were continued throughout the year, but nothing was done to place the furnace again in commission. The typical ore at the Goldbanks is cinnabar, which occurs in small stringers and finely disseminated through an extremely hard light-colored quartzitic rock, which is locally termed quartzite, but which preliminary field examination shows to be almost certainly a silicified rhyolite flow breccia with probably some silicified massive rhyolite. The ore thus far mined constituted an irregular mass about 350 feet long, 100 feet wide, and

20 feet thick. This was mined by open-cut methods. The ore, so far as ascertainable at the time of visit late in 1917, probably does not continue as an extensive body below a depth of about 50 feet, but there is still a large quantity of ore exposed in the walls of the pit and the extent of the ore both laterally and downward is far from definitely known.

The only other production reported from Humboldt County was by the Lovelock Quicksilver Mines Co., which operated twelve 12-inch pipe retorts near Antelope Springs, about 22 miles southeast of Lovelock, for a part of the year only. There is a fairly large quantity of low-grade ore in the vicinity of Antelope Springs, of which a considerable part is on land belonging to the Southern Pacific Co. The remainder is divided between three or four owners or groups of owners. The ore occurs mainly as cinnabar dispersed through masses of shattered limestone conglomerate or breccia that rest, as remnants left by erosion, on the crests of ridges and hills of soft shale. It is doubtful whether any of the ore extends to a greater depth than 50 feet, and no indication was seen that any ore occurs in the underlying shale.

MINERAL COUNTY.

About 14 miles east of Mina, in the Pilot Mountains, the Farnham & Drew, or Red Devils mine, worked under lease and bond by the Mina Quicksilver Co., produced a considerable quantity of quicksilver from high-grade ore treated in two D retorts, a bank of 12 pipe retorts being unused. The ore occurs as lenticular bodies in disturbed shale, and some of the best of it is said to contain 1.2 ounces of gold and 44.4 ounces of silver to the ton, with 25 per cent of lead and 18 per cent of quicksilver. Such ore apparently consists mainly of massive rather ocherous cinnabar with carbonate of lead and a yellow powdery mineral that has not yet been studied but which resembles massicot, the yellow oxide of lead. At the time of visit the mine was 150 feet deep on an incline of about 45°. Early in 1918 the lessees exhausted the ore in sight and abandoned operations.

The Lost Steers group, in the same district, was worked in a small way by a lessee who produced some quicksilver from superficial cuts, with a single D retort. The Cinnabar King was idle in 1917, after a total production amounting in all to only about 30 flasks. The general geology of the Pilot Mountains deposits has been described by Knopf.[1]

The Mount Montgomery mine is situated on a spur on the north side of Mount Montgomery, in the White Mountain Range, at an elevation of about 9,100 feet. It is 5 miles by a good mountain road from Mount Montgomery station, on the Carson & Colorado Railroad. The ore occurs in a remnant of a rhyolitic flow, about 250 feet thick, that apparently rests on andesite. The rhyolite, a glassy, brittle variety, has been much fractured and in part altered to a white, pulverulent material. The ore consists largely of a soft, powdery mixture of cinnabar with the altered rhyolite. Work in 1917 consisted chiefly of development and the erection of two D retorts, although a few tons of ore were retorted at Belleville and yielded some quicksilver.

---

[1] Knopf, Adolph, Some cinnabar deposits in western Nevada: U. S. Geol. Survey Bull. 620, pp. 59–62, 1916.

At Belleville some quicksilver was produced as a by-product in treating tailings for their silver and gold contents.

NYE COUNTY.

No production was reported from the cinnabar deposits east of Beatty, described in 1916 by Knopf.[1] The property of the Denver Bullfrog Cooperative Mining Co., on Meiklejohn Mountain, was sold by the sheriff of Nye County and is now reported to be owned by the Telluride Group Mines Co.

In the Ione district the Nevada Cinnabar Co. made no production. The large ore body in rhyolite, which was worked by open-cut mining, is exhausted, and although some attempts were made in 1917 to find additional ore, these had not been successful at the end of the year.

The Mercury Mining Co., whose mine lies about a mile north of that of the Nevada Cinnabar Co., carried on prospecting during the later part of the year with such success that the 25-ton Scott furnace was started in October and a small production made.

A very brief examination of this mine was made in October, 1917, and the following notes give merely a general characterization of the deposit. The rocks exposed in the vicinity of the mines are impure limestones, hard shales, and a thick bed of very hard siliceous breccia. They are in contact on the west with a broad belt of ancient greenstones and on the east with the Tertiary rhyolites, here faulted down against them. These older rocks are probably of Carboniferous age. The ore occurs near and partly within a neck of coarse agglomerate containing abundant boulders and angular fragments of soft altered rhyolite, the largest 4 or 5 feet in diameter, together with boulders and fragments of the older rocks. This mass of agglomerate probably fills a hole blown through the older rocks by a volcanic explosion at the time of the Tertiary rhyolitic eruptions of the region. The ore in the inclosing rocks is found chiefly as cinnabar in cracks and crevices in shattered limestone, but also to some extent in shale in the limestone. That in the agglomerate generally occurs as an impregnation of the chalky rhyolite boulders with cinnabar.

A very small output of quicksilver was made from a superficial pocket of cinnabar found by prospectors near the crest of the Shoshone Mountains, north of Ione and 12 miles west of Bowler's ranch on Reese River.

OREGON.

Occurrences of cinnabar are widely distributed through Oregon, but only one, that at Blackbutte in Lane County, produced on a considerable scale. Some of the numerous prospects in the southwestern part of the State give promise, however, of becoming productive mines.

DOUGLAS COUNTY.

The Elkhead mine, 6 miles southwest of Blackbutte and the same distance southeast of Yoncalla, near Elkhead post office, lay idle for

---

[1] Knopf, Adolph, op. cit., pp. 62–67.

15 or 16 years, but in 1917 the mine changed hands, the plant was overhauled, and a two months' test run was made with the 20-ton Scott furnace. No production, however, was reported. The ore occurs in soft, bleached, much altered andesitic rock, probably in part at least a tuff, which has been faulted down by a westward-dipping fault so as to be in contact with shale along its eastern boundary. The ore formerly worked formed an irregular flat-lying body about 10 feet thick that extended westward into the hill from the fault and evidently resembled in general character that of the Black Butte mine, presently to be described.

JACKSON COUNTY.

The following note on quicksilver deposits, mostly in Jackson County, is supplied by J. T. Pardee, of this Survey:

Deposits containing quicksilver are reported here and there in a belt 10 or 15 miles wide that extends northward 25 miles or more from a point a few miles northeast of Medford, Oreg. The belt lies from 10 to 20 miles east of the Southern Pacific Railroad and covers part of the western slopes and spurs from the Cascade Mountains in Jackson and Douglas counties. At the north of the area a prospect is reported on Drew Creek, 4 or 5 miles south of Drew post office, Douglas County. It is reached by a road and trail 40 miles long from Riddles and is said to be promising but undeveloped. Another undeveloped prospect is said to lie about a mile south of Rogue River at the mouth of Elk Creek, a point about 30 miles from Medford on the road to Crater Lake. Films and specks of cinnabar are reported by Henry M. Parks, director of the Oregon Bureau of Mines and Geology, as occurring on seams in volcanic tuff at a point about 3 miles southeast of Brownsboro, Jackson County. Within the belt mentioned, however, practically all the deposits that have been developed to any noteworthy extent are in the Meadows mining district north and south of Evans Creek about 20 miles above its mouth at Rogue River on the Southern Pacific Railroad. North of Evans Creek, named in order, are the Little Jean mine owned by Dr. W. P. Chisholm of Gold Hill, the Cinnabar Nos. 1 and 2 claims of B. F. Peart, of Central Point, Oreg., and the Blue Jay, Homestead, Rainier, and other claims of the Rainier Quicksilver Co. The Mountain King mine, owned in Detroit, Mich., is south of the creek on the slope west of Ramsey Canyon and about 2 miles southwest of the Little Jean. In addition, some undeveloped prospects are reported a mile southeast of the Little Jean. The area through which all the different deposits mentioned are distributed is 3 or 4 miles long and a mile or more in width.

The Meadows district is conveniently reached from Gold Hill or Rogue River on the Southern Pacific Railroad by auto roads. The surface is mountainous and moderately rough, the local relief ranging from 500 to 1,500 feet. Streams are fairly numerous and the slopes thickly timbered. There are several farms along Evans Creek.

The prevailing formation is a dark-gray quartz mica schist that grades into shale or argillite on one hand and into sandstone on the other. It is highly inclined and cut by dikes and irregular branching bodies of a moderately fine light-gray porphyry, most of the exposures of which are badly decomposed and rusty with iron oxides. At the Mountain King mine a fine-grained gray granitoid rock is exposed, which is presumably a part of the same body as the porphyry. In places along Evans Creek the schist is also cut by pegmatite dikes.

The main porphyry body extends from a point north of the Homestake claim, where it appears as a dike 100 feet wide, southward a mile or more, where it expands to a width of at least 1,000 feet. A narrower dike several hundred feet long has a general east and west course through the Rainier claim. The Mountain King granite area is irregular, but at least 500 feet wide in places.

The porphyry is severely and the granite moderately sheared and crushed, and so far as they could be observed the predominant shear planes have a general east-west direction.

Along some of the numerous sheared and brecciated zones the porphyry is partly altered to a jaspery quartz that crops out rather prominently. Generally the weathered layer of the crushed porphyry is rich in iron oxides. Here and there small veins and stringers of quartz or of calcite are abundant. Water level appears to be generally within a few feet of the surface.

In places the oxidized porphyry breccia shows films and specks of cinnabar on the seams, and some of it in the Rainier lode looks to be fairly rich in quicksilver. Below water level in the Rainier cinnabar, together with much pyrite and some quartz and calcite, fills spaces in the partly silicified breccia. According to reports, a little cinnabar can generally be panned from the surface mantle throughout the area of altered porphyry. As cinnabar was seen at several widely separated places, this statement is probably true.

On the Mountain King, according to Mr. Pardee, there are 8 or 10 tunnels at elevations from 2,400 to 3,000 feet, which are said to have a total length of 2,500 feet. The principal tunnel is on the slope west of Ramsey Creek, at an elevation of 2,550 feet, or 500 feet above that stream. Together with its branches, it has a length of 600 feet and attains a depth of at least 200 feet. Tunnels at points 50 and 150 feet lower aggregate about 400 feet.

The workings examined by Mr. Pardee on the Mountain King showed, in July, 1918, some small veins and stringers of quartz and calcite, some of which are banded with pyrite, and also some rather persistent but narrow zones of breccia. A little cinnabar was seen at one place near the mouth of the tunnel at an elevation of 2,400 feet, and some native quicksilver is said to have been found in this tunnel. No production was reported in 1917.

At the Little Jean mine the 12 Johnson-McKay retorts were reset and a very small production was made. According to H. G. Ferguson, of this Survey, who visited the mine in November, 1917, the Little Jean is about 18 miles north-northwest of Gold Hill, on a branch of Evans Creek, at an elevation of 2,500 feet. The workings are near the top of a rather steep hill and comprise about 300 feet of irregular tunnels with a maximum depth of about 40 feet. The country rock is shale and sandstone, the shale predominating, much sheared and faulted, but generally dipping north to northeast at low angles. The cinnabar, with some native quicksilver, occurs in a gougy fault zone from 3 to 6 inches wide.

No production was reported in 1917 from the Rainier mine, then in possession of the Utah Quicksilver Co. The claims formerly held by this company and some additional ones have since been acquired by the Rainier Quicksilver Co., and active work was in progress in 1918. The following notes are based on information furnished from the field by Mr. Pardee, who visited the mine in July, 1918.

At that time the company was developing the mine on two levels and also preparing to reopen an old shaft on the Homestake claim. The 12 Johnson-McKay retorts were in operation and considerable production had been made.

Workings on the Rainier claim consisted of two short crosscut tunnels, 50 feet apart vertically, with about 200 feet of drifts. The greatest depth reached was about 70 feet. About 1,500 tons of ore, averaging over 1 per cent of quicksilver, of which ore perhaps half would average over 3 per cent, had been blocked out on July 20, 1918, and the outlook for finding large additions to the ore already known seemed good.

LANE COUNTY.

The Black Butte mine, 16 miles south of Cottage Grove, was operated throughout the year on very low grade ore, which was treated in a 36-ton Scott furnace with Dennis patented vitrified pipe condensers. Experiments in flotation were carried out and proved so satisfactory that early in 1918 a flotation mill of about 40 tons capacity was added to the plant. The ore occurs as cinnabar, with a little native quicksilver, in a fissure zone in andesite and andesitic breccia, which, near the ore bodies, have been altered to a light-gray to white, rather soft rock with stringers of hard brown material formed by the segregation of iron oxide along cracks. The cinnabar forms small stringers, rarely over an inch in width, and is also distributed as small specks through the altered rock. Marcasite and pyrite are in places associated with the cinnabar and occasionally masses of black, fibrous carbonaceous material, probably carbonized wood, and irregular stringers of stibnite, are found in the workings. The main stope is about 180 feet long, about 15 feet wide, and has been carried from the surface nearly to the 400-foot level. The mine is worked through tunnels, and the ore is carried down to the furnace by an aerial tramway. The total cost of mining and treatment, according to Mr. E. B. Crane, the superintendent, is $2.68 a ton. The furnace consumes from 1½ to 2 cords of wood a day, which costs, delivered, from $2 to $2.50 a cord.

MALHEUR COUNTY.

In the southeast corner of the State, about 11 miles west-northwest of McDermitt, a small town on the Oregon-Nevada line, some prospecting was done on a group of 12 claims over which cinnabar is rather widely distributed. Here a flow of rhyolite, 100 feet or more in thickness, is exposed on the south slope of a basalt-capped ridge and is overlain by hot-spring deposits, patches of leaf-bearing lacustrine shale, with layers of diatomaceous earth, and some sandy tuff beds. The rhyolite is silicified but so far as could be seen from the shallow pits and trenches contains very little cinnabar. The cinnabar occurs chiefly in the porous, siliceous hot-spring sinter and in the lake beds. Not enough work had been done in 1917 to determine whether the deposits have economic value, but they were reported early in 1918 to have been sold, and presumably additional prospecting will be carried on.

TEXAS.

PRODUCTION.

There were 4 producing mines in Texas in 1917, all in Brewster County. The ore treated amounted to 28,242 short tons and yielded 10,791 flasks of quicksilver, valued at $1,136,508. In 1916 25,945 tons yielded 6,306 flasks, valued at $793,862. The production of Texas from the beginning of operations in the Terlingua district to date is given in the following table:

Quicksilver produced in Texas, 1899–1917.

Year.	Quantity (flasks).	Price per flask.	Value.	Year.	Quantity (flasks).	Price per flask.	Value.
1899	1,000	$47.70	$47,700	1910	3,320	$46.51	$154,413
1900	1,800	44.94	80,892	1911	2,326	46.01	107,019
1901	2,932	48.46	142,085	1912	1,990	42.05	83,680
1902	5,319	43.20	229,781	1913	2,750	40.23	110,633
1903	5,029	45.29	227,763	1914	3,144	49.05	154,213
1904	5,336	43.50	232,116	1915	4,417	85.80	378,979
1905	4,723	36.22	171,067	1916	6,306	125.89	793,862
1906	4,761	39.50	188,060	1917	10,791	105.32	1,136,508
1907	3,686	39.60	145,966				
1908	2,382	44.17	105,213		76,200	....	4,680,295
1909	4,188	45.45	190,345				

BREWSTER COUNTY.

The Chisos mine in the Terlingua district continued to be the most productive quicksilver mine in Texas and the second in rank in the United States, being surpassed only by the New Idria in California. It is also the deepest mine in the district.

The Chisos ore bodies occur along a strong curved fault zone with a generally nearly east and west trend. The course of the fault is concave to the north, the dip on the whole nearly vertical, and the downthrow along the main ore-bearing part of the zone apparently nowhere in the mine exceeds 60 feet, although there has evidently been a considerable horizontal component of the movement in the fault plane. The mine has three operating shafts and the workings open the fault zone for a length of about 2,500 feet and to a depth of 750 feet, by levels generally 50 feet apart vertically. The rocks exposed in the mine from the surface downward are the thinly laminated yellowish shales correlated with the Austin chalk, probably not over 50 feet thick at the mine; the thin-bedded, flaggy, more or less sandy shales and limestones known as the Eagle Ford formation, here about 500 feet thick; the Buda limestone, 100 feet thick; the Del Rio clay, 75 to 100 feet thick, and the thick-bedded Edwards limestone. The Austin chalk and Eagle Ford formations are Upper Cretaceous and the Buda limestone, Del Rio clay, and Edwards limestone are Lower Cretaceous. The ore of the Chisos mine occurs chiefly in the Buda limestone, but above the 550-foot level large quantities have been stoped also from the overlying Eagle Ford, and some was found early in 1918 on the 700-foot level in the Edwards limestone, exploration of which at this locality has barely begun, chiefly because it lies below water level. This limestone has supplied most of the ore of the Mariposa and other mines west of the Chisos.

From the surface to the 600-foot level the ore bodies occurred at intervals nearly all along the explored portion of the fault zone, especially where this consists of several fissures or is joined by cross fissures. Below the 600-foot level, however, most of the ore—and the richest that has yet been found in the mine—forms a single remarkable chimney, from 75 to 100 feet in diameter, that extends from a little above the 600-foot level to the 750-foot level and perhaps deeper. Although the 700-foot and 750-foot levels are nearly all in Del Rio clay, the ore chimney is in a mass of shattered Buda limestone, which probably has been faulted down into the clay shale, perhaps as a consequence of the collapse of a solution chamber in the massive Edwards limestone. The ore in this dropped mass is a chaotic breccia consisting chiefly of fragments of Buda limestone with cinnabar, native quicksilver, free sulphur, and marcasite or pyrite, and perhaps other minerals less readily recognizable, as an interstitial filling and as a replacement of some of the smaller limestone fragments. The large output of the Chisos mine during the last three or four years has come almost entirely from this one rich ore body.

The Chisos ore is treated in a skillfully handled 20-ton Scott furnace with brick condensers. A rotary furnace 65 feet long and 54 inches in diameter, with a 12-inch lining of fire brick, was completed some time ago but was reset at a higher angle (7°) early in 1918 and may now be in operation. This furnace has a separate condensing system of combined brick chambers with Cermak elliptical vitrified pipes about 12 by 18 inches in section.

At the Mariposa mine (formerly the Marfa and Mariposa) extensive superficial prospecting was carried out, in the course of which considerable quicksilver was produced in one of the two 10-ton Scott furnaces. The mine changed ownership in October, and more extensive work was planned for 1918, including the operation of the 50-ton Scott furnace of the Terlingua Mining Co., whose ground has been leased to the Mariposa Mining Co. All of the ore treated in 1917 was taken from shallow pits and trenches in the Edwards limestone, chiefly on the east side of California Hill, the operations extending over an area about a mile long and half a mile wide. The ore occurs in a broad zone of nearly east-west fissures, some of which are traceable for half a mile or more, although others are much shorter. Many of them, although well defined and accompanied by considerable brecciation near the surface, become very indistinct and carry no ore below a depth of 50 feet or less. A very persistent fissure, that of the Margaret D. vein, lies about 500 yards north of the Mariposa group of fissures, with a curving but generally nearly east and west strike. This shows cinnabar at many places, and was formerly worked at the Colquitt-Tignor mine and, farther west, for a short time by the Mariposa company. The ore shoots are reported to be generally rather narrow and of lower grade than those near California Hill. No underground work was being done in California Hill at the time of visit, in March, 1918, although a large part of the total quicksilver obtained from this mine, said to amount to about 27,000 flasks, was obtained from stopes in this hill, especially from those near the so-called phonolite dike and at or near the contact of the Del Rio clay with the underlying Edwards limestone.

At Study Butte, in the eastern part of the Terlingua district, the Study Butte Mining Co., operating the Big Bend mine, made a fairly large production, exceeded only by that of the Chisos Mining Co., in Texas, and those of the New Idria, New Guadalupe, and New Almaden companies, in California. The ore, after sorting to a little more than half of the material broken, and to a grade slightly above one-half of 1 per cent, was treated in a 50-ton Scott furnace.

At Study Butte the beds of the Eagle Ford formation have been separated by an intrusive sheet, from 400 to 500 feet thick, of light-gray porphyry, whose exact petrographic character has not yet been determined. The porphyry forms the crest of the butte and, with the shales above and below it, dips to the north, apparently at about 60° near the crest of the hill but becoming nearly horizontal at the base of the north slope. The ore occurs on the north side of the butte in and near a series of northwest-southeast fissures, especially for short distances above and below the contact of the porphyry with the overlying shale. The cinnabar in the fissures is generally associated with a calcite gangue.

In the Dallas mine, owned by the Texas Almaden Mining Co. and lying just east of the Big Bend, the ore apparently occurs mainly as a nearly horizontal layer in the Eagle Ford formation, immediately above the porphyry. The Dallas mine, like the Big Bend, is under lease to W. D. Burcham and associates, and preparations were being made early in 1918 to pump it out and resume work.

Prospecting for quicksilver was not generally active in the Terlingua district in 1917, but the Rainbow Mining Co., on ground just west of the Chisos mine, was attempting to find an ore shoot in the westward continuation of the Chisos fault zone.

Outside of the Terlingua district the Ellis mine, sometimes called the 34 mine, situated 6 miles south-southwest of McKinney Springs post office, between the Chisos Mountains and the Rio Grande, was opened in June and by the end of the year had made a considerable production with retorts from high-grade ore.

The mine is in the Eagle Ford formation, which in its vicinity contains numerous dikes and intrusive sheets of igneous rocks of various kinds. The ore was discovered at the lower contact of an inclined dike that apparently was intruded along a thrust plane which dips northwest about 35°, or a little more steeply than the beds above and below it. When the ore had been followed down for 50 to 60 feet it was found to turn into a nearly vertical fissure, which in places forms two slightly diverging branches. The ore along this fissure is in places 5 feet wide and continues to the 100-foot level, where another intrusive rock appears in which the fissures are barren. A 50-foot winze from the 100-foot level passes through this rock, and ore was just appearing in a short crosscut under it at the time of visit in March, 1918.

The three retorts in which the ore was being treated in 1917 are of unusual design, consisting of specially cast tubes about 16 inches in diameter and 12 feet long set at an angle of 45°. They are charged at the top, the two end ones every 8 hours and the middle one every 6 hours, and discharge at the bottom. About one-half of the contents are removed before each charging and the total capacity of the three retorts is about 4 tons in 24 hours, with a consumption of 1½ cords of wood. A manifold collects the quicksilver vapor and conducts it into small vitrified pipe condensers. These retorts are said to be satisfactory, and larger ones were to be installed in 1918. They are much more convenient to charge and discharge than the ordinary retorts, but there is probably considerable loss of quicksilver, especially in the operation of charging.

UTAH.

No production of quicksilver was reported in Utah in 1917, although from 1903 to 1907 this State produced 3,338 flasks and the annual production in 1905 rose to 1,133 flasks. Practically all of this came from the Sacramento gold mine in the Mercur district and from the sulphoselenide ores near Marysvale.

WASHINGTON.

There was no output of quicksilver from Washington, and apparently very little prospecting or development work done in that State in 1917.

BIBLIOGRAPHY OF QUICKSILVER IN NORTH AMERICA.

Compiled by Isabel P. Evans.

This bibliography comprises all references found on the history of the early California quicksilver mines, the occurrence of mercury minerals in North America, the machinery used in handling these minerals, descriptions of mercury lamps, and also articles on the chemistry, physics, and metallurgy of quicksilver. The list of serials comprises only those which have been examined from their beginning to the end of 1917. Reviews have not been included unless they contained original matter.

SERIALS EXAMINED.

Alaska and Northwest Mining Journal. Seattle, Wash.
American Institute of Mining Engineers: Transactions. Philadelphia, Easton, Pa.; New York, N. Y.
American Journal of Science. New York, N. Y.; New Haven, Conn.
Arizona State Bureau of Mines: Annual Report; Bulletin. Tucson, Ariz.
Boston Society of Natural History: Proceedings. Boston, Mass.
British Columbia Mining Record; continued as British Columbia Mining and Engineering Record. Victoria, B. C.
California Academy of Sciences: Proceedings. San Francisco, Cal.
California State Mining Bureau: Annual Report; Bulletin. San Francisco, Cal.
California, University of, Department of Geology: Bulletin. Berkeley, Cal.
Canada, Department of Mines, Mines Branch: Annual Report; Bulletin. Ottawa, Ontario.
Canada Geological Survey: Summary Report. Ottawa, Ontario.
Canadian Mining Institute: Monthly Bulletin; Transactions. Toronto and Ottawa, Ontario.
Canadian Mining Manual. Ottawa and Toronto, Ontario.
Canadian Mining Review; continued as Canadian Mining Journal. Toronto, Ontario.
Colorado Geological Survey: Bulletin. Denver, Colo.
Economic Geology. Lancaster, Pa.
Engineering and Mining Journal. New York, N. Y.
Federated Institution of Mining Engineers: Transactions. *See also* Institution of Mining Engineers. Newcastle upon Tyne, England.
Idaho State Inspector of Mines: Annual Report. Boise, Idaho.
Institution of Mining and Metallurgy: Bulletin; Transactions. London, England.
Institution of Mining Engineers: Transactions. Newcastle upon Tyne, England.
Journal of Industrial and Engineering Chemistry. Easton, Pa.
Manufacturers Record. Baltimore, Md.
Metallgesellschaft: Annual Issue. Frankfort-on-the-Main, Hesse-Nassau, Germany.
Metallurgical and Chemical Engineering. New York, N. Y.
Mexican Mining Journal. Mexico City, D. F.
Mineral Industry. New York and London.
Mines and Minerals or Colliery Engineer. Scranton, Pa. Incorporated with Coal Age, November 6, 1915. New York, N. Y.
Mining American. Denver, Colo.
Mining and Engineering World. Chicago, Ill. Incorporated with Engineering and Mining Journal, January 6, 1917.
Mining and Scientific Press. San Francisco, Cal.
Mining and Statistic Magazine; continued as Mining Magazine and Journal of Geology. New York.
Mining Magazine. London, England.
Mining Magazine. New York, vols. 1–9, 1853–1857; continued as Mining and Statistic Magazine, vol. 10–vol. 11, No. 4, 1858; continued as Mining Magazine and Journal of Geology, etc., 2d ser., vols. 1–2 (whole number, vols. 11–12), November, 1859–January, 1861 [no more published].

Mining Magazine. New York, vols. 10–13, 1904–1906; incorporated with Engineering and Mining Journal, Aug. 1, 1906. This magazine is the continuation of the Pacific Coast Miner, which would have begun its tenth volume July 1, 1904, "which explains why the magazine takes this volume and number." (Min. Mag., vol. 10, p. 42, 1904.)
Mining Reporter; continued as Mining Science; continued as Mining American. Denver, Colo.
Mining Science; continued as Mining American. Denver, Colo.
Mining World; continued as Mining and Engineering World. Chicago, Ill. Incorporated with Engineering and Mining Journal January 6, 1917.
Nevada State Mineralogist: Report. Carson, Nev.
Oregon Bureau of Mines and Geology, Mineral Resources of Oregon. Corvallis, Oreg.
Oregon University: Bulletin. Eugene, Oreg.
Salt Lake Mining Review. Salt Lake City, Utah.
Science. New York, N. Y.
Scientific American. New York, N. Y.
Scientific American Supplement. New York, N. Y.
Sociedad científica "Antonio Alzate": Memorias y Revista. Mexico City, D. F.
Texas Academy of Sciences: Transactions. Austin, Tex.
Texas Geological Survey: Annual Report. Austin, Tex.
Texas Mineral Resources. Austin, Tex.
Texas, University of: Bulletin. Austin, Tex.
United States Geological Survey: Annual Reports; Bulletins; Geological Atlas of the United States, folios; Mineral Resources; Monographs; Professional Papers. Washington, D. C.
Washington (State) Geological Survey: Bulletin. Olympia, Wash.

INDEX TO BIBLIOGRAPHY.[1]

Alaska.
  Alaska and Northwest Mining Journal, 1, 2.
  Brooks, A. H., 1–8.
  Hinckley, F. C., 1.
  McCaskey, H. D., 6, 9, 11–13.
  Mertie, J. B., jr., and Harrington, G. L., 1.
  Mining and Engineering World, 4.
  Prindle, L. M., 1.
  Smith, P. S., 1.
  Smith, P. S., and Maddren, A. G., 1.
  Spurr, J. E., and Post, W. S., 1.
Arizona.
  Arizona, University of, 1.
  Bancroft, H., 1, 2.
  Dennis, C. G., 6.
  Dennis, C. G., and Bogard, V. E., 1.
  Hill J. M., 1.
  Horton, F. W., 1.
  Joseph, P. E., 1.
  McCaskey, H. D., 1, 2, 4–6, 9, 11–13.
  Mineral Industry, 6.
  Mining and Engineering World, 5.
  Mining and Scientific Press, 35.
  Ransome, F. L., 6.
  Thom, W. T., 3, 4, 6.
  Turner, H. W., 5, 6.
  Willis, C. F., 1, 2.
British Columbia.
  Becker, G. F., 7.
  British Columbia Mining Record, 1.
  Camsell, C., 1.
British Columbia—Continued.
  Dawson, G. M., 1.
  Hoffman, G. C., 1–3.
  Merritt, W. H., 1.
  Mineral Industry, 6.
  Monckton, G. F., 1.
  Ontario Bureau of Mines, 1.
California.
  American Quicksilver Co., 1.
  Anonymous, 1, 2.
  Arnold, R., and Anderson, R., 1.
  Aubury, L. E., 1.
  Becker, G. F., 7–10.
  Black, G. F., 1, 2.
  Blake, W. P., 1–3, 10.
  Boalich, E. S., 1–3.
  Bradley, W. W., 1–4.
  Brown, G. C., 1.
  Browne, J. R., 1, 2.
  California Senate and Assembly Journal, 1, 2.
  California State Mining Bureau, 1–3.
  Caslamayomi Rancho, 1.
  Castillero, A., 1.
  Christy, S. B., 2–4.
  Crawford, J. J., 1, 2.
  De Kalb, C., 1.
  Demaret, L., 1.
  Dennis, C. G., 6, 8.
  Dennis, C. G., and Bogard, V. E., 1.
  Dolbear, S. H., 1.
  Eakle, A. S., 2.
  Eddy, L. H., 1–8.

---

[1] The numerals given in this index are the numbers prefixed to the titles of the citations in the bibliography, pp. 432–455. Thus under the heading "Uses" the references to "Becker, G. F., 1" and "Mining and Scientific Press, 26" are, respectively, to the article on quicksilver and fuel by Becker (Min. and Sci. Press, Feb. 13, 1875) and to the article on the Use and care of mercury, published in Min. and Sci. Press for Aug. 17, 1907.

California—Continued.
Edwards, C. E., 1.
Egleston, T., 1.
Emmons, W. H., 1.
Engineering and Mining Journal, 1, 3, 5, 9–11, 18, 19, 27.
Fairbanks, H. W., 1.
Forstner, W., 1, 2.
Gillan, S. L., 1.
Goodyear, W. A., 1.
Guadalupe Mining Co., 1.
Hamilton, F., 1–4.
Hanks, H. G., 1–3.
Harper's New Monthly Magazine, 1.
Hart, T. S., 1.
Heberlein, C. A., 1.
Hess, F. L., 1.
Hewett, A. S., 1.
Hill, J. M., 1.
Horton, F. W., 1.
Ingalls, W. R., 1.
Innes, M., 1.
Lake Quicksilver Mining Co., 1.
Lakes, A., 1.
Lake Valley Quicksilver Mining Co., 1.
Landers, W. H., 1, 2.
Lawson, A. C., 1.
LeConte, J., and Rising, W. B., 1.
Lindgren, W., 1.
Lindgren, W., and Turner, H. W., 1, 2.
Lowell, F. L., 1, 2.
Lyman, C. S., 1.
Lytle, J. A., 1.
McCaskey, H. D., 1–7, 9, 11–13.
McGarrahan, W., 1, 2.
McNeely, W. M., 1.
Mason, R. B., 1.
Melville, W. H., 1.
Melville, W. H., and Lindgren, W., 1.
Metallgesellschaft, 1–8.
Mineral Industry, 1–5, 8, 13–14, 16, 18–20.
Mining American, 3.
Mining and Engineering Review, 2.
Mining and Engineering World, 3, 9.
Mining and Scientific Press, 1, 3–13, 15–18, 21–24, 28, 36, 41–42.
Mining and Statistic Magazine, New York, 1–4.
Mining Magazine, New York, 1–5.
Mining Magazine and Journal of Geology, 1.
Mining Science, 2, 5.
New Almaden mine, 1–5.
New Idria Mining Co., 1.
Newcomb, B. M., 1.
Newland, D. H., 1.
Nöggerath, A., 1.
Osmont, V. C., 1.
Panoche Grande Quicksilver Mining Co., 1.
Panoche Grande Rancho, 1.
Parker, E. W., 1–3.
Phillips, J. A., 1.
Phillips, J. A., and Louis, H., 1.

California—Continued.
Place, R. G., 1.
Pošepný, F., 1, 2.
Powell, J. W., 1–4.
Purnell, S., 1.
Quicksilver Mining Co., 1–17.
Randol, J. B., 1–9.
Ransome, F. L., 1.
Rath, G. v., 1.
Raymond, R. W., 1–4, 5–7, 9–10.
Revista Semanal, 1.
Ries, H., 1.
Rogers, A. F., 1, 2.
Rolland, G., 1.
Salt Lake Mining Review, 4.
San Francisco Commercial Herald, 1.
Santa Clara Mining Association, 1.
Shaw, C. P., 1.
Silliman, B., jr., 1.
Skidmore, W. A., 1, 2.
Storms, W. H., 1.
Struthers, J., 1–3.
Thom, W. T., 1–5.
Turner, H. W., and Ransome, F. L., 1.
Tyson, P. T., 1.
Van Wagenen, T. F., 1.
Veatch, J. A., 1.
Vivian, W., 1.
Wagoner, L., 1, 2.
Walcott, C. D., 1–4, 6–7, 9–11.
Watts, W. L., 1–6.
Wells, W. V., 1.
Whitney, J. D., 3–5.
Williams, A., jr., 1, 2, 4, 5, 7.
Yale, C. G., 1–11.
Canada. *See also* British Columbia, Nova Scotia, and Ontario.
Buisson, A., 1.
Colquhoun, A. L., 1.
Hore, R. E., 1.
Hunt, T. S., 1.
McLeish, J., 1–5, 6.
Mineral Industry, 6–11, 15.
Young, G. A., 1.
Chemistry and physics.
Baly, E. C. C., 1.
Becker, G. F., 5, 7–10.
Blagden, Charles, 1.
Broderick, T. M., 1.
Burdick, A. J., 1.
Carson, J. P., 1.
Chemical Society, London, 1.
Chism, R. E., 1.
Clarke, F. W., 1, 2.
Colvin, V., 1.
Davis, H. S., 1.
Dunnicliffe, H. B., 1.
Emmons, W. H., 3.
Engineering, 1.
Engineering and Mining Journal, 2.
Forbes, G. S., and Richter, H. W., 1.
Grout, F. E., 1.
Hanks, H. G., 5.
Horton, F. W., 1.
Hovey, E. O., 1.
Huff, W. B., 1.
Hutchins, T., 1, 2.

Chemistry and physics—Continued.
Imperial Institute, London, 1.
Jameson, R., 1.
Jamieson, G. S., 1.
Lake Valley Quicksilver Mining Co., 1.
LeConte, J., and Rising, W. B., 1.
Lindgren, W., 2, 5–7.
McLennan, J. C., 1.
Mallet, J. W., 1.
Mellor, J. W., 1.
Mineral Industry, 5, 11.
Mining and Scientific Press, 43.
Ostwald, W., 1.
Penfield, S. J., 1.
Pošepný, F., 1, 2.
Raymond, R. W., 4.
Rickard, T. A., and Ralston, O. C., 1.
Schaller, W. T., 1.
Schrauf, A., 1.
Scientific American, 2.
Scientific American Supplement, 1–3.
Smith, S. W. J., and Moss, H., 1.
Stillman, M. H., 1.
Tate, J. T., 1.
Wilhelm, R. M., 1.

Colorado.
Emmons, W. H., 1.
Endlich, F. M., 1.
Freeman, H. C., 1.
Mineral Industry, 4.
Smith, J. A., 1.
Williams, A., jr., 2, 7.

Demand.
Engineering and Mining Journal, 15, 16, 26.
McCaskey, H. D., 1–2, 4–6, 9–13.
Manufacturers Record, 1.
Mining and Scientific Press, 4, 26, 29, 40, 42.
Mining Science, 3.
Raymond, R. W., 5, 6.
Smith, G. O., 2.
Yale, C. G., 2–3, 5–10.

Description.
Achiardi, A. d', 1.
Allen, E. T., and Crenshaw, J. L., 1.
Bagley, W. S., 1.
Beck, R., 1.
Becker, G. F., 4, 10.
Browne, J. R., 1.
Butler, G. M., 1.
Egleston, T., 1.
George, R. D., 1, 2.
Hanks, H. G., 4.
Haverstock, R. S., 1.
Joseph, P E., 1.
Lindgren, W., 7.
McCaskey, H. D., 5.
Mining and Scientific Press, 20.
Moses, A. J., and Parsons, C. L. 1.
Penfield, S. J., 1.
Phillips, J. A., 1.
Richardson, C. H., 1.
Ries, H., 1.

Description—Continued.
Spencer, L. J., 1.
Van Wagenen, T. F., 1.
Whitney, J. D., 1.
Young, G. A., 1.

Geology.
Becker, G. F., 2, 3, 6, 7–10.
Blake, W. P., 5.
Broderick, T. M., 1.
Browne, J. R., 1.
Christy, S. B., 1.
Clevenger, G. H., 1.
Durand, F. E., 1, 2.
Emmons, S. F., and Becker, G. F., 1.
Emmons, W. H., 2, 3.
Joseph, P. E., 1.
Kemp, J. F., 2.
King, C., 1.
Krusch, P., 1.
Le Conte, J., 1, 2.
Le Conte, J., and Rising, W. D., 1.
Lindgren, W., 6–8.
McCaskey, H. D., 6–8.
Moore, G. E., 1.
Pardee, J. T., and Hewett, D. F., 1.
Phillips, W. B., 13.
Pošepný, F., 1.
Richardson, C. H., 1.
Schrauf, A., 1.
Turner, H. W., 9.
Udden, J. A., 2, 3.
Van Wagenen, T. F., 1.
Veatch, J. A., 1, 2.
Virlet d'Aoust, P. T., 1.
Wagoner, L., 2.
Weaver, C. E., 1.
Weed, W. H., 1, 2.
Whitney, J. D., 1.

Idaho.
Becker, G. F., 7.
Bell, R. N., 1, 2.
Blake, W. P., 4.
McCaskey, H. D., 6, 9, 11–13.
Williams, A., jr., 7.

Machinery and lamps.
Becker, G. F., 1.
Brown, C. F., 1.
Dennis, C. G., 1.
Desha, L. J., 1.
Egleston, T., 1.
Electrical Review and Western Electrician, 1.
Electrical World, 1.
Emmet, W. L. R., 1, 2.
Engineering and Mining Journal, 21–23.
Fawcett, W., 1.
Geary, J. W., 1.
Hageman, I., 1.
Horton, F. W., 1.
James, G. A., 1.
Knipp, C. T., 1, 2.
Kraus, C. A., 1.
Langmuir, I., 1.

Machinery and lamps—Continued.
Metallurgical and Chemical Engineering, 1.
Mineral Industry, 4, 10, 11.
Newman, J., 1.
Patten, H. E., and Mains, G. H., 1.
Purnell, S., 1.
Robertson, M., 1.
Scientific American, 1.
Struthers, J., 2.
Williams, A., jr., 1.

Maps.
Gannett, H., 1.
Geary, J. W., 1.
Hill, R. T., 1.
Map of Alaska, 1.
Topographic map, Brewster County, Tex., 1.
Topographic map, Brewster and Presidio counties, Tex., 2.

Metallurgy.
Aubury, L. E., 2.
Austin, L. S., 1.
Booth, F. J., 1.
Carey, E. E., 1.
Christy, S. B., 2–4.
Clennell, J. E., 1.
Dennis, C. G., 2, 5–7.
Dennis, W. B., 3.
Egleston, T., 1, 2.
Engineering and Mining Journal, 7, 8, 20.
Feust, A., 1.
Geary, J. W., 2.
Hague, A., 1.
Hamilton, E. M., 1.
Hanks, H. G., 3.
Heberlein, C. A., 1.
Hewitt, A. S., 1.
Horton, F. W., 1.
Imperial Institute, London, 1.
Janin, L., jr.
Juretzka, F., 1.
Lamb, M. R., 1.
Landers, W. H., 3.
Lang, H., 1.
McCaskey, H. D., 1, 13.
McNeely, W. M., 1.
Mactear, J., 1.
Mexican Mining Journal, 1, 2.
Mineral Industry, 4, 8, 15–17.
Mining American, 3.
Mining and Engineering Review, 1.
Mining and Engineering World, 7, 8.
Mining and Scientific Press, 2, 14, 19, 24, 25, 34, 39, 45.
Mining Journal, London, 1.
Moore, G. E., 1.
Mosher, D., 1.
Mulholland, C. A., 1–3.
Murray, B. L., 1, 2.
Northey, G. V., 1.
Prather, J. K., 1.
Purnell, S., 1.

Metallurgy—Continued.
Raymond, R. W., 8.
Richardson, C. H., 1.
Scott, R., 1.
Seamon, W. H., 1.
Sharwood, W. J., 1, 2.
Smith, R. O., 1.
Spirek, V., 1.
Stovall, D. H., 3.
Strauss, L. W., 1.
Struthers, J., 2.
Symington, R. B., 1.
Szilard, B., 1.
Thornhill, E. B., 1–4.
Turner, H. W., 4–6, 8.
Watson, R. B., 1.
Whitton, W. W., 1.

Mexico.
Aguilera, J. G., 1.
Babb, P. A., 1.
Barriga, M. D., 1.
Blake, W. P., 9.
Bonney, W. L., 1, 2.
Brush, G. J., and Comstock, W. J., 1.
Capilla, A., 1.
Castillo, A. del., 1, 2.
Collins, H. F., 1.
Encyclopaedia Britannica, 1.
Engineering and Mining Journal, 14.
Flores, T., 1.
Gabb, W. M., 1.
Galeoti, H., 1.
Halse, E., 1, 2.
Hill, R. T., 1.
Hillebrand, W. F., 1.
Hillebrand, W. F., and Schaller, W. T., 1.
Humboldt, A., 1.
Laguerenne, T. L., 1.
McNeely, W. M., 1.
Merrill, F. J. H., 1.
Mineral Industry, 1–13, 15, 16.
Mining and Engineering World, 1.
Mining and Scientific Press, 27, 30.
Mining Reporter, 2.
Newland, D. H., 1.
Nöggerath, A., 1.
Phillips, J. A., and Louis, H., 1.
Ramirez, S., 1, 2.
Rangel, M., 1.
Raymond, R. W., and Ingalls, W. R., 1.
Revista Semanal, 1.
Rundall, W. H., 1.
Sandberger, F., 1.
Sanford, S., and Stone, R. W., 1.
Struthers, J., 2.
Thomas, K., 1.
Van Wagenen, T. F., 1.
Villarello, J. D., 1–3.
Whitney, J. D., 1.

Montana.
Emmons, W. H., 3.
Emmons, W. H., and Calkins, F. C., 1.

Nevada.
- Becker, G. F., 7.
- Blake, W. P., 7.
- Burgess, J. A., 1.
- Davis, W. C., 1.
- Dennis, C. G., 6, 8.
- Dennis, C. G., and Bogard, V. E., 1.
- Eakle, A. S., 1.
- Emmons, W. H., 3.
- Engineering and Mining Journal, 11, 17, 24.
- Higgins, W. C., 1.
- Hill, J. M., 1.
- Horton, F. W., 1.
- Knopf, A., 1.
- Lindgren, W., 5, 8.
- McCaskey, H. D., 1–2, 4–6, 8–9, 11–13.
- Mineral Industry, 6, 16.
- Mining American, 1.
- Mining and Scientific Press, 42.
- Parker, E. W., 2, 3.
- Powell, J. W., 1.
- Ransome, F. L., 2–5.
- Raymond, R. W., 7, 9.
- Salt Lake Mining Review, 2.
- Shockley, W. S., 1.
- Thom, W. T., 4–6.
- Turner, H. W., 6, 7, 9.
- Walcott, C. D., 6, 10, 11.
- Whitehill, H. R., 1.
- Whitney, J. D., 2.
- Williams, A., jr., 2, 7.

Nova Scotia.
- Becker, G. F., 7.
- How, H., 1.

Ontario.
- Miller, W. G., 1.
- Ontario Bureau of Mines, 2.
- Thornhill, E. B., 4.

Oregon.
- Butler, G. M., and Mitchell, G. J., 1.
- Crane, E. B., 1.
- Demaret, L., 1.
- Dennis, C. G., and Bogard, V. E., 1.
- Dennis, W. B., 1, 2.
- Diller, J. S., and Kay, G. F., 1.
- Emmons, W. H., 2.
- Hill, J. M., 1.
- Horton, F. W., 1.
- Lindgren, W., 2, 3.
- McCaskey, H. D., 1–2, 4–6, 9, 11–13.
- Mineral Industry, 16.
- Mining and Scientific Press, 37.
- Mitchell, G. J., 1.
- Newland, D. H., 1.
- Oregon Bureau of Mines and Geology, 1.
- Pardee, J. T., and Hewett, D. F., 1.
- Parks, H. M., 1.
- Parks, H. M., and Swartley, A. M., 1.
- Raymond, R. W., 9.
- Stafford, O. F., 1.
- Stovall, D. H., 1, 2, 4.
- Struthers, J., 2, 3.

Oregon—Continued.
- Thom, W. T., 1, 3, 4.
- Todd, A., 1.
- Turner, H. W., 5–7.
- Walcott, C. D., 3, 7.
- Wendeborn, B. A., 1.
- Williams, A., jr., 7.
- Winchell, A. N., 1.

Prices.
- Becker, G. F., 7, 10.
- Boutwell, J. M., 1.
- Bradley, W. W., 4.
- Browne, J. R., 2.
- Day, D. T., 1–14, 16–25.
- Dennis, C. G., 3, 4–8.
- Eddy, L. H., 1–8.
- Emmons, S. F., 1.
- Emmons, S. F., and Becker, G. F., 1.
- Engineering and Mining Journal, 16, 18, 25.
- Hanks, H. G., 3.
- Horton, F. W., 1.
- Imperial Institute, London, 1.
- Joseph, P. E., 1.
- Kemp, J. F., 1.
- Krusch, P., 1.
- Lowell, F. L., 1.
- McCaskey, H. D., 1–2, 4–6, 9, 11–13.
- McLeish, J., 1–5, 6.
- Metallgesellschaft, 1–8.
- Mining and Scientific Press, 42.
- Mining Industry, 1–22.
- Pickering, A. H., 1.
- Pitaval, R., and Ganet, L., 1.
- Powell, J. W., 2–5.
- Randol, J. B., 2–9.
- Raymond, R. W., 1–3, 5–7, 9–10.
- Smith, P. S., 1.
- Struthers, J., 2–5.
- Thom, W. T., 1–6.
- Turner, H. W., 7–9.
- Walcott, C. D., 1–11.
- Williams, A., jr., 1, 3–6.
- Yale, C. G., 1, 3–10.

Santo Domingo.
- Courtney, W. S., 1.

Texas.
- Blake, W. P., 8.
- Burcham, W. D., 1.
- Canfield, F. A., Hillebrand, W. F., and Schaller, W. T., 1, 2.
- Cummins, W. F., 1.
- Davis, L. H., 1.
- Day, D. T., 15.
- Demaret, L., 1.
- Dennis, C. G., 1, 5, 6, 8.
- Dennis, C. G., and Bogard, V. E., 1.
- Dinsmore, C. A., 1.
- Emmons, W. H., 3.
- Hill, B. F., 1–3.
- Hill, J. M., 1.
- Hill, R. T., 1, 2.
- Hornaday, W. D., 1.
- Horton, F. W., 1.

Texas—Continued.
Kirk, M. P., 1.
Kirk, M. P., and Malcolmson, J. W., 1.
Koch, W. E., 1.
McCaskey, H. D., 1–2, 4–6, 9, 11–13.
Mineral Industry, 4, 8, 13, 14, 20.
Mining and Scientific Press, 32, 42, 44.
Mining Reporter, 1.
Moses, A. J., 1, 2.
Newland, D. H., 1.
Parker, E. W., 1–3.
Phillips, W. B., 1–12, 14–23, 24.
Ries, H., 1.
Schaller, W. T., 1.
Simonds, F. W., 1.
Spalding, E. P., 1.
Struthers, J., 1–3.
Texas Mineral Resources, 1.
Thom, W. T., 1–5.
Turner, H. W., 2–3, 5–7, 9.
Udden, J. A., 1–3.
Udden, J. A., and Baker, C. L., 1.
Walcott, C. D., 6, 7, 9–11.

United States.
Becker, G. F., 7, 10.
Boutwell, J. M., 1.
Clark, M. B., 1.
Day, D. T., 1–14, 16–25.
Dennis, C. G., 3–8.
Dennis, C. G., and Bogard, V. E., 1.
Dunlop, J. P., 1.
Eddy, L. H., 1–8.
Emmons, S. F., 1.
Emmons, S. F., and Becker, G. F., 1.
Engineering and Mining Journal, 12, 13, 16.
Horton, F. W., 1.
Imperial Institute, London, 1.
Joseph, P. E., 1.
Kemp, J. F., 1.
Krusch, P., 1.
Lowell, F. L., 1.
McCaskey, H. D., 1–2, 4–6, 9–13.
Metallgesellschaft, 1–8.
Mineral Industry, 1–21.
Mining American, 2.
Mining and Engineering World, 3, 6.
Mining and Scientific Press, 31, 38, 40.
Mining Science, 4.
Newland, D. H., 1.
Nöggerath, A., 1.
Parker, E. W., 1–3.
Phillips, J. A., and Louis, H., 1.
Pickering, A. H., 1.
Powell, J. W., 5.
Randol, J. B., 7.
Raymond, R. W., and Ingalls, W. R., 1.
Ries, H., 1.
Salt Lake Mining Review, 2.
Schrader, F. C., Stone, R. W., and Sanford, S., 1.
Schrauf, A., 1.
Smith, G. O., 2.

United States—Continued.
Struthers, J., 1–5.
Thom, W. T., 1–5.
Turner, H. W., 5–7, 9.
Walcott, C. D., 5, 8, 9.
Whitney, J. D., 1.
Williams, A., jr., 1, 3–6.

Uses.
Becker, G. F., 1, 7, 10.
Bradley, W. W., 4.
Colvin, V., 1.
Dennis, C. G., 8.
George, R. D., 2.
Hanks, H. G., 2.
Horton, F. W., 1.
Imperial Institute, London, 1.
McCaskey, H. D., 1, 2, 6, 7, 9, 11–13
Mining American, 2.
Mining and Scientific Press, 26, 42.
Mining Science, 3.
Pitaval, R., and Ganet, L., 1.
Richardson, C. H., 1.
Ries, H., 1.
Salt Lake Mining Review, 3.
Smith, P. S., 1.
Van Wagenen, T. F., 1.
Williams, A., jr., 4, 5.
Wolf, A. G., 1.

Utah.
Beason, L. H., 1.
Becker, G. F., 7.
Blake, W. P., 6.
Brush, G. J., and Comstock, W. J., 1.
Demaret, L., 1.
Emmons, W. H., 3.
Horton, F. W., 1.
Lindgren, W., 4.
McCaskey, H. D., 1–2, 4–6, 9, 11–13.
Mining Magazine, New York, 1.
Struthers, J., 2.
Thom, W. T., 1, 2.
Williams, A., jr., 7.

Washington.
Dennis, C. G., and Bogard, V. E., 1.
McCaskey, H. D., 4, 6, 9, 11–13.
Mining and Scientific Press, 33.
Smith, G. O., 1.
Weaver, C. E., 1.

World's production.
Becker, G. F., 7, 10.
Boutwell, J. M., 1.
Dennis, C. G., 6–8.
Eddy, L. H., 1–8.
Engineering and Mining Journal, 16.
Horton, F. W., 1.
Imperial Institute, London, 1.
Joseph, P. E., 1.
Krusch, P., 1.
Lindgren, W., 7.
McCaskey, H. D., 1–2, 4–6, 9–13.
Metallgesellschaft, 1–8.
Mineral Industry, 1–21.
Mining and Engineering World, 2, 6.

World's production—Continued.
Mining and Scientific Press, 29, 31, 38.
Mining Magazine, New York, 6.
Newland, D. H., 1.
Pickering, A. H., 1.

World's production—Continued.
Pitaval, R., and Ganet, L., 1.
Struthers, J., 1–5.
Turner, H. W., 5–7.
Van Wagenen, T. F., 1.
Williams, A., jr., 1, 4–6.

BIBLIOGRAPHY.

Achiardi, Antonio d'. 1. I metalli loro minerali e minere [mercurio]; vol. 1, pp. 100–110, 120–124, 1883.

Aguilera, J. G. 1. The geographical and geological distribution of the mineral deposits of Mexico [mercury]: Am. Inst. Min. Eng. Trans., vol. 32, pp. 508–509, 1902.

Alaska and Northwest Mining Journal. 1. Quicksilver deposits in Alaska: Vol. 7, No. 4, pp. 73–74, 1 fig., October, 1915.

——— 2. Quicksilver in Jackson County, Oreg.: Vol. 11, No. 1, p. 4, July, 1917.

Allen, E. T., and Crenshaw, J. L. 1. The sulphides of zinc, cadmium, and mercury; their crystalline forms and genetic conditions [metacinnabar]: Am. Jour. Sci., 4th ser., vol. 34, pp. 373–381, 1912.

American Quicksilver Co. of California. 1. Mercury, 29 pp., New York, 1849. Pamphlet.

Anonymous. 1. History of the mineral and allodial titles of the quicksilver mines on the Rancho de los Capitancillos, about 60 miles from San Francisco, in Santa Clara County, Cal., 16 pp., New York, 1858. Pamphlet.

——— 2. Exploits of the Attorney General in California, by an early Californian; dated August 10, 1860, 80 pp., New York, 1860. Gives a brief history of the quicksilver mines of California and the early claimants to them. Pamphlet.

Arizona, University of. 1. Mineralogy of useful minerals in Arizona [cinnabar]: Bull. 41 (Econ. ser. 11), p. 30, 1916–1917.

Arnold, Ralph, and Anderson, Robert. 1. Geology and oil resources of the Coalinga district, Cal. [investigation of quicksilver]: U. S. Geol. Survey Bull. 398, p. 16, 1910.

Aubury, L. E. 1. The quicksilver resources of California: California State Min. Bur. Bull. 27, 273 pp., 50 pls., 94 figs., 8 maps, 1903.

——— 2. Metallurgy of quicksilver: Min. World, vol. 19, pp. 20–22, 8 figs., Dec. 5; pp. 21–22, 9 figs., Dec. 12, 1903.

Austin, L. S. 1. The metallurgy of the common metals [mercury], 2d ed., pp. 126–127, 244, San Francisco, 1909.

Babb, P. A. 1. Dulces Nombres quicksilver deposit, Mexico: Eng. and Min. Jour., vol. 88, pp. 684–686, 4 figs., Oct. 2, 1909.

Bagley, W. S. 1. Descriptive mineralogy: Determinative mineralogy [mercury], pp. 52, 62–63, 489, New York and London, 1917.

Baly, E. C. C. 1. Inorganic chemistry [critical temperature of mercury]: Chem. Soc. Ann. Rept., vol. 12, p. 44, 1916.

Bancroft, Howland 1. Notes on the occurrence of cinnabar in central western Arizona: U. S. Geol. Survey Bull. 430, pp. 151–153, 1910.

——— 2. Reconnaissance of the ore deposits in northern Yuma County, Ariz. [quicksilver and cinnabar]: U. S. Geol. Survey Bull. 451, pp. 44–45, 84, 1911.

Barriga, M. D. 1. Mining in Mexico [cinnabar]: Mining Jour. (London), vol. 77, p. 455, Apr. 29, 1905.

Beason, L. H. 1. Quicksilver from Sacramento mine, Mercur district, Utah: Mineral Industry, vol. 15, p. 357, 1907.

Beck, Richard. 1. The nature of ore deposits, vol. 2, pp. 350–360, 1905. [Trans. by W. H. Weed.]

Becker, G. F. 1. Quicksilver and fuel: Min. and Sci. Press, vol. 30, pp. 98, 102, Feb. 13, 1875.

——— 2. The relations of the mineral belts of the Pacific slope to the great upheavals: Am. Jour. Sci., 3d ser., vol. 28, pp. 209–212, 1884.

——— 3. Geology of quicksilver: U. S. Geol. Survey Fourth Ann. Rept., pp. 40–41, 1884.

——— 4. Statistics and technology of the precious metals; geological sketch of the Pacific division [cinnibar, metacinnabarite, and quicksilver]: Tenth Census of the United States, vol. 13, pp. 10, 15, 16, 23–28, 1885.

Becker, G. F. 5. Natural solutions of cinnabar, gold, and associated sulphides: Am. Jour. Sci., 3d ser., vol. 33, pp. 199–210, 1887.

———6. Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Seventh Ann. Rept., pp. 93–94, 96, 1888.

———7. Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, 486 pp., 7 pls., and atlas of 14 sheets folio, 1888.

———8. Summary of the geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Eighth Ann. Rept., pt. 2, pp. 961–985, pls. lxii–lxiii, 1889.

———9. Investigations of quicksilver deposits of the Pacific slope: U. S. Geol. Survey Ninth Ann. Rept., pp. 100–101, 1889.

———10. Quicksilver ore deposits: U. S. Geol. Survey Mineral Resources, 1892, pp. 139–168, 1893.

Bell, R. N. 1. Mining industry of Idaho [mercury]: Idaho State Inspect. Mines Fourteenth Ann. Rept., p. 47, 1912.

———2. Quicksilver: Idaho State Inspect. Mines Nineteenth Ann. Rept., pp. 95–96, 1917.

Black, J. S. 1. Report of the Attorney General [on the New Almaden quicksilver mine] to the President on the resolutions of the Legislature of California, 10 pp., Washington, 1860.

———2. The notes on the history of quicksilver in California, in the case of the United States *vs.* Andreas Castillero, decided by the Supreme Court, December term, 1862: U. S. Supreme Court Repts., vol. 67 [vol. 2 of Black series], pp. 42, 84–88, 147–148, 349, 1862 [1863].

Blagden, Charles. History of the congelation of quicksilver: Philos. Trans., vol. 73, pp. 329–397, 1783.

Blake, W. P. 1. Quicksilver mine of [New] Almaden, California (from a letter to J. D. Dana, dated San Francisco, Feb. 14, 1854): Am. Jour. Sci., 2d ser., vol. 17, pp. 438–440, 1854.

———2. Mercury; Santa Clara County, New Almaden; Guadalupe mine; Monterey County: Am. Jour. Sci., 2d ser., vol. 20, p. 80, 1855.

———3. Annotated catalogue of the principal mineral species hitherto recognized in California and the adjoining States and Territories [cinnabar and mercury]: Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains [for 1866], pp. 202, 207, 1867.

———4. Mineralogical notices, No. 2; Cinnabar in calcite in Idaho: California Acad. Nat. Sci. Proc., vol. 3, p. 298, 1867.

———5. Note on the occurrence of gold with cinnabar in the Secondary or Tertiary rocks: Boston Soc. Nat. Hist. Proc., vol. 11, pp. 30–31, 1868.

———6. Notes on some points in the mineralogy and geology of Utah: Am. Jour. Sci., 3d ser., vol. 2, p. 216, 1871.

———7. The ore deposits of Eureka district, eastern Nevada: Am. Inst. Min. Eng. Trans., vol. 6, pp. 554–563, 1879.

———8. Cinnabar in Texas: Am. Inst. Min. Eng. Trans., vol. 25, pp. 68–76, 1896.

———9. Notes on the mines and minerals of Guanajuato, Mexico [cinnabar]: Am. Inst. Min. Eng. Trans., vol. 32, pp. 220, 223, 1902.

———10. Minerals of Arizona, their occurrence and association [cinnabar]: a report to the Hon. J. H. Kibbey, governor of Arizona, p. 15, 1909.

Boalich, E. S. 1. Mineral production for 1911 [quicksilver]: California State Min. Bur. Bull. 69, pp. 30–31, 1912.

———2. Mineral production for 1912 [quicksilver]: California State Min. Bur. Bull. 65, pp. 19–20, 1913.

———3. Mineral production for 1913 [quicksilver]: California State Min. Bur. Bull. 68, pp. 23–24, 1914.

Bonney, W. 1. Mineral resources of San Luis Potosi, Mexico [quicksilver mines]: Min. and Eng. World, vol. 38, p. 720, Apr. 12, 1913.

———2. Mineral resources of San Luis Potosi [quicksilver]: Mexican Min. Jour., vol. 16, No. 6, p. 281, June, 1913.

Booth, F. J., The reduction of quicksilver ore: Min. and Sci. Press, vol. 93, pp. 570–572, Nov. 10, 1906.

Boutwell, J. M. 1. Quicksilver: U. S. Geol. Survey Mineral Resources, 1906, pp. 491–499, 1907.

Bradley, W. W. 1. Mines and minerals of Fresno and Kings counties [quicksilver] (chapters of State mineralogist's report, 1913–14), pp. 6, 36–38, 100, 102–104, California State Min. Bur., July, 1915.

Bradley, W. W. 2. Mines and mineral resources of the counties of Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo [quicksilver] (chapters of State mineralogist's report, 1913–14), pp. 17, 27, 54–68, 111–120, 139–140, 170–179, 197, California State Min. Bur., illus., July, 1915.

———3. California mineral production for 1915 [quicksilver]: California State Min. Bur. Bull. 71, pp. 33–35, August, 1916.

———4. California mineral production for 1916 [quicksilver]: California State Min. Bur. Bull. 74, pp. 42–47, August, 1917.

British Columbia Mining Record, Savonas cinnabar properties: Vol. 7, pp. 375–376, October, 1900.

Broderick, T. M. 1. Some experiments bearing on the secondary enrichment of mercury deposits: Econ. Geology, vol. 11, No. 7, pp. 645–651, October-November, 1916.

Brooks, A. H. 1. The mining industry in 1905 [prospecting for cinnabar deposits in Alaska]: U. S. Geol. Survey Bull. 284, p. 9, 1906.

———2. Mineral deposits of Alaska [occurrence of cinnabar]: U. S. Geol. Survey Bull. 592, pp. 36–37, 1914.

———3. Mining and mineral wealth of Alaska [occurrence of cinnabar], p. 26, Washington, D. C., Judd & Detweiler, 1909.

———4. Geologic features of Alaska metalliferous lodes [occurrence of cinnabar]: U. S. Geol. Survey Bull. 480, p. 93, 1911.

———5. The Alaskan mining industry in 1914 [quicksilver]: U. S. Geol. Survey Bull. 622, pp. 21, 67, 1915.

———6. The Alaskan mining industry in 1915: Iditarod district [antimony-cinnabar lodes]: U. S. Geol. Survey Bull. 642, p. 66, pl. 1 (map, in pocket), 1916.

———7. Antimony deposits of Alaska [stibnite-cinnabar lodes]: U. S. Geol. Survey Bull. 649, p. 12, 1916.

———8. Alaska's mineral supplies, introduction [quicksilver]: U. S. Geol. Survey Bull. 666–P, p. 9, 1917.

Brown, C. F. 1. Oil-burning mercury retort, furnace, and condenser: Min. Reporter, vol. 55, p. 355, Apr. 18, 1907.

Brown, G. C. 1. Mines and minerals of Shasta, Siskiyou, and Trinity counties, Cal. [quicksilver] (chapters of State mineralogist's report, 1913–14), pp. 126, 131–132, 179–180, California State Min. Bur., July, 1915.

Browne, J. R. 1. Quicksilver mines of California: Mineral resources of the States and Territories west of the Rocky Mountains [for 1866], pp. 170–178, 1867.

———2. Quicksilver: Mineral Resources of the States and Territories west of the Rocky Mountains [for 1867], op. 263–264, 636, 1868.

Brush, G. J., and Comstock, W. J. 1. On American sulphoselenides of mercury, with analyses of onofrite from Utah: Am. Jour. Sci., 3d ser., vol. 21, pp. 312–316, 1881.

Buisson, Arthur. 1. The production of copper, gold, lead, nickel, silver, zinc, and other metals [mercury]: Canada Dept. Mines, Mines Branch Ann. Rept. on mineral production 1916, p. 41, 1917. [Advance chapter.]

Burcham, W. D. 1. Quicksilver in Terlingua, Tex.: Eng. and Min. Jour., vol. 103, p. 97, Jan. 13, 1917.

Burdick, A. J. 1. Chemical tests for minerals [native mercury and cinnabar], pp. 55–56, Beaumont, Cal., Gateway Publishing Co., 1917.

Burgess, J. A. 1. The halogen salts of silver and associated minerals at Tonopah, Nev. [cinnabar]: Econ. Geology, vol. 6, No. 1, p. 21, January–February, 1911.

Butler, G. M. 1. A pocket handbook of minerals [cinnabar, mercury], 1st ed., pp. 55–56, Beaumont, Cal., Gateway Publishing Co., 1917.

Butler, G. M., and Mitchell, G. J. 1. Preliminary survey of the geology and mineral resources of Curry County, Oreg. [mercury and cinnabar]: Oregon Bur. Mines and Geology, Mineral Resources of Oregon, vol. 2, No. 2, p. 72, October, 1916.

California Senate and Assembly Jour. 1. Fifteenth sess., Appendix, vol. 2 [Mining review for 1863, quicksilver, p. 193], 1864.

———2. Sixteenth sess., Appendix, vol. 3 [Mining review for 1865, quicksilver, pp. 332–333], 1866.

California State Mining Bureau. 1. California mineral production for 1915 [quicksilver]; Bull. 71, pp. 33–35, August, 1916.

———2. California's mineral production for 1915 [quicksilver]; Press Bull. 37, p. 2, Aug. 25, 1916.

California State Mining Bureau. 3. Quicksilver in California; its military importance; no commercial substitute yet developed; Press Bull. 40, 1 p., May 15, 1917.

Camsell, Charles. 1. The mineral resources of a part of the Yale district, British Columbia; a descriptive summary [mercury]: Canadian Min. Inst. Quart. Bull. 12, p. 129, October, 1910.

Canfield, F. A., Hillebrand, W. F., and Schaller, W. T. 1. Mosesite, a new mercury mineral from Terlingua, Tex.: Am. Jour. Sci., 4th ser., vol. 30, pp. 202–208, 1910.

———2. Mosesit, ein neues Quecksilbermineral von Terlingua, Tex.: Zeitschr. Kryst. Min., Leipzig, vol. 49, pp. 1–8, 1911.

Capilla, Alberto. 1. Breves anotaciones sobre la mina de mercurio "La Guadalupana," San Luis Potosi [Mexico]: Soc. cient. Ant. Alzate, Mem. y Rev., vol. 13, pp. 423–427, 1904.

Carey, E. E. 1. Principles of electrolytic amalgamation: Min. World, vol. 32, pp. 896–897, Apr. 30, 1910.

Carson, J. P. 1. The mineral district of Chiquilistlan [Mexico]: Am. Inst. Min. Eng. Trans., vol. 6, pp. 405–406, 1879.

Caslamayomi Rancho. 1. Sonoma County, Cal., 17 pp., [about 1865]. Pamphlet.

Castillero, Andreas. 1. *See* J. S. Black, U. S. Supreme Court Repts., vol. 67 [vol. 2 of Black], 1862.

Castillo, Antonio del. 1. Resumen de los trabajos que sobre reconocimientos de criaderos y minas de azogue se practicaron el año 1844: La Naturaleza, vol. 2, pp. 39–120, 1871.

———2. Quicksilver mining in Mexico: Min. and Sci. Press, vol. 30, p. 41, Jan. 16, 1875.

Chemical Society, London. 1. Inorganic analysis; detection and estimation of mercury: Ann. Rept. 1916, vol. 13, pp. 182–186, 1917.

Chism, R. E. 1. A new assay for mercury: Am. Inst. Min. Eng. Trans., vol. 28, pp. 444–452, 1 fig., 1899.

Christy, S. B. 1. On the genesis of cinnabar deposits: Am. Jour. Sci., 3d ser., vol. 17, pp. 453–463, 1879.

———2. Quicksilver reduction at New Almaden, Cal.: Am. Inst. Min. Eng. Trans., vol. 13, pp. 547–584, 6 pls., 1885.

———3. Quicksilver reduction at New Almaden [California]: U. S. Geol. Survey Mineral Resources, 1883 and 1884, pp. 503–536, 1885.

———4. Quicksilver-condensation at New Almaden [California]: Am. Inst. Min. Eng. Trans., vol. 14, pp. 206–265, 1886.

Clarke, F. W. 1. . . . on the electrolytic estimation of mercury: Am. Jour. Sci., 3d ser., vol. 16, pp. 200–201, 1878.

———2. The data of geochemistry [mercury]: U. S. Geol. Survey Bull. 330, pp. 17, 572–577, 1908; 2d ed., Bull. 491, pp. 18, 633–638, 1911; 3d ed., Bull. 616, pp. 18, 664–669, 1916.

Clennell, J. E. 1. Volumetric estimation of mercury: Eng. and Min. Jour., vol. 98, pp. 787–789, Oct. 31, 1914.

Clevenger, G. H. 1. Note upon the occurrence of mercury in cobalt ores: Econ. Geology, vol. 10, pp. 770–773, December, 1915.

Collins, H. F. 1. Quicksilver mining in the district of Guadalcazar, State of San Luis Potosi, Mexico: Inst. Min. and Met., London, vol. 4, pp. 121–150, 1896.

Colquhoun, A. L. 1. Notes on the occurrence of quicksilver in Canada: Canadian Min. Inst. Jour., vol. 1, pp 13–16, 1899; Canadian Min Rev., vol. 18, pp. 41–42, 1899; summary, Min. and Sci. Press, vol. 79, p. 288, Sept. 9, 1899.

Colvin, Verplanck. 1. On certain new phenomena in chemistry; an account of mercury and its amalgams: Albany Inst. Trans., vol. 7, pp. 172–185, 1872.

Courtney, W. S. 1. The gold fields of St. Domingo [" mercury at the head of the River Yaque "], p. 119, New York, 1860.

Crane, E. B. 1. Difficult mine sampling [method employed at Black Butte quicksilver mine, Lane County, Oreg.]: Min. and Sci. Press, vol. 114, p. 539, Apr. 21, 1917.

Crawford, J. J. 1. Report of State mineralogist [quicksilver]: California State Min. Bur., Twelfth Rept., pp. 358–372, 1894.

———2. Report of State mineralogist [quicksilver]: California State Min. Bur., Thirteenth Rept., pp. 594–604, 1896.

Cummings, W. F. 1. Mining districts in El Paso County, Tex.: Texas State Geol. and Sci. Assoc. Geol. and Sci. Bull., vol. 1, No. 2 [p. 3], 1888.

Davis, H. S. 1. The rhythmic precipitation of colloidal mercury: Am. Chem. Soc. Jour., vol. 39, pp. 1312–1314, 1 fig., July, 1917.

Davis, L. H. 1. West Texas mining notes: Texas Mineral Resources, vol. 1, No. 1, p. 2, November, 1916.

Davis, W. C. 1. Quicksilver in Nevada: Min. and Sci. Press, vol. 99, p. 663, Nov. 13, 1909.

Dawson, G. M. 1. Report on explorations in British Columbia; cinnabar on the Homathco: Canada Geol. Survey Rept. Prog. for 1876–1877, p. 133, 1878.

———2. The mineral wealth of British Columbia [occurrence of mercury]: Canada Geol. Survey Ann. Rept., new ser., vol. 3, pt. 2, pp. 105R, 156R, 1889.

———3. Report on the area of the Kamloops map sheet, British Columbia [mercury on Copper Creek]: Canada Geol. Survey Ann. Rept., new ser., vol. 7, pp. 340–341, 1896.

Day, D. T. 1. Quicksilver: U. S. Geol. Survey Mineral Resources, 1886, pp. 160–168, 1887.

———2. Quicksilver: U. S. Geol. Survey Mineral Resources, 1887, pp. 2, 6, 8, 9, 118–125, 1888.

———3. Quicksilver vermilion: U. S. Geol. Survey Mineral Resources, 1887, p. 679, 1888.

———4. Statistics of quicksilver: U. S. Geol. Survey Eighth Ann. Rept., pt. 1, p. 196, 1889.

———5. Statistics of quicksilver: U. S. Geol. Survey Ninth Ann. Rept., pp. 135, 139, 1889.

———6. Statistics of quicksilver: U. S. Geol. Survey Tenth Ann. Rept., pt. 1, p. 183, 1890.

———7. Quicksilver: U. S. Geol. Survey Mineral Resources, 1888, pp. 2, 97–107, 1890.

———8. Quicksilver vermilion: U. S. Geol. Survey Mineral Resources, 1888, p. 622, 1890.

———9. Statistics of quicksilver: U. S. Geol. Survey Twelfth Ann. Rept., pt. 1, pp. 130–131, 1891.

———10. Quicksilver: U. S. Geol. Survey Mineral Resources, 1889 and 1890, pp. 2, 6, 94–109, 1892.

———11. Quicksilver in 1891: U. S. Geol. Survey Mineral Resources, 1891, pp. 1–2, 117–125, 1893.

———12. Summary of production of quicksilver in 1892: U. S. Geol. Survey Mineral Resources, 1892, p. 2, 1893.

———13. Quicksilver in 1893: U. S. Geol. Survey Mineral Resources, 1893, pp. 2, 111–118, 1894.

———14. Quicksilver in 1893: U. S. Geol. Survey Fifteenth Ann Rept., p. 204, 1895.

———15. Quicksilver in 1894; discovery of, in Texas: U. S. Geol. Survey Sixteenth Ann. Rept., pt. 3, pp. 6, 598–604, 1895.

———16. Quicksilver in 1895: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 3, pp. 7, 179–184, 1896.

———17. Quicksilver; summary of production: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 5, pp. 6, 287–290, 1897.

———18. Quicksilver; summary, imports, production since 1850, prices: U. S. Geol. Survey Nineteenth Ann. Rept., pt. 6, pp. 5, 243–248, 1898.

———19. Quicksilver; summary, production, imports, and prices: U. S. Geol. Survey Twentieth Ann. Rept., pt. 6, pp. 7, 271–275, 1899.

———20. Quicksilver in 1900: U. S. Geol. Survey Mineral Resources, 1900, pp. 15, 235–238, 1901.

———21. Quicksilver in 1901: U. S. Geol. Survey Mineral Resources, 1901, p. 18, 1902.

———22. Quicksilver in 1902: U. S. Geol. Survey Mineral Resources, 1902, pp. 13–14, 1904.

———23. Quicksilver in 1903: U. S. Geol. Survey Mineral Resources, 1903, pp. 13–14, 281–284, 1904.

———24. Quicksilver in 1904: U. S. Geol. Survey Mineral Resources, 1904, pp. 12, 295–299, 1905.

———25. Quicksilver in 1905 (summary): U. S. Geol. Survey Mineral Resources, 1905, pp. 14–15, 1906.

De Kalb, Courtenay. 1. Guadalupe quicksilver works [California]: Min. and Sci. Press, vol. 100, pp. 446–447, figs., Mar. 26, 1910.

Demaret, Léon. 1. Les principaux gisements des minérais de mercure du monde [United States, California, Oregon, Texas, Utah]: Annales des mines de Belgique, vol. 9, pp. 46–66, 1904.

Dennis, C. G. 1. Rare mercury ores [Texas]: Min. and Sci. Press, vol. 95, p. 92, 2 figs., July 20, 1907.

———2. Modern quicksilver reduction: Min. and Sci. Press, vol. 99, p. 761, Dec. 4, 1909.

———3. Quicksilver production and prices: Min. and Sci. Press, vol. 106, pp. 61–62, Jan. 4, 1913.

———4. Quicksilver production and prices: Min. and Sci. Press, vol. 108, pp. 81–82, Jan. 3, 1914.

———5. Quicksilver: Mineral Industry, vol. 22, pp. 651–656, 1914.

———6. Quicksilver in 1914: Min. and Sci. Press, vol. 110, pp. 91–92, Jan. 9, 1915.

———7. Quicksilver: Mineral Industry, vol. 23, pp. 654–659, 1915.

———8. Quicksilver: Mineral Industry, vol. 24, pp. 614–619, 1916.

Dennis, C. G., and Bogard, V. E. 1. Quicksilver: Mineral Industry, 1916, vol. 25, pp. 638–640, 1917.

Dennis, W. B. 1. The quicksilver deposits of Oregon: Eng. and Min. Jour., vol. 76, pp. 539–541, 2 figs., Oct. 10, 1903.

———2. Quicksilver in Oregon: Mineral Industry, vol. 16, pp. 815–816, 1908.

———3. Shortening the roasting period for mercury: Eng. and Min. Jour., vol. 88, pp. 112–116, 6 figs., July 17, 1909.

Desha, L. J. 1. An apparatus for the purification of mercury: Am. Chem. Jour., vol. 41, pp. 152–155, 1 fig., February, 1909.

Diller, J. S. 1. Quicksilver: U. S. Geol. Survey Geol. Atlas, Roseburg folio (No. 49), [p. 4], 1898.

———2. Mineral resources of southwestern Oregon [quicksilver]: U. S. Geol. Survey Bull. 546, p. 129, 1914.

Diller, J. S., and Kay, G. F. 1. Mineral resources of the Grants Pass quadrangle and bordering districts, Oreg. [cinnabar]: U. S. Geol. Survey Bull. 380, p. 79, 1909.

Dinsmore, C. A. 1. Quicksilver deposits of Brewster County, Tex.: Min. World, vol. 31, pp. 877–878, 6 figs., Oct. 30, 1909.

Dolbear, S. H. 1. Chemical resources of California [quicksilver]: Met. and Chem. Eng., vol. 12, No. 11, p. 721, November, 1914.

Dunlop, J. P. 1. Metals and ores in 1914 and 1915 [production of quicksilver]: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 726, 1916.

Dunnicliffe, H. B. 1. A simple method for the purification of mercury: Chem. News, vol. 116, No. 3009, pp. 41–42, 1 fig., July 27, 1917.

Durand, F. E. 1. Note on crystals of quartz of a red color, by the interposition of cinnabar: California Acad. Sci. Proc., vol. 4, p. 211, 1873.

———2. Notes on the crystallization of metacinnabarite: California Acad. Sci. Proc., vol. 4, pp. 219–220, 1873.

Eakle, A. S. 1. The minerals of Tonopah, Nev.: California Univ. Dept. Geology Bull., vol. 7, p. 8, 1912.

———2. Minerals of California [cinnabar, mercury, and metacinnabarite]: California State Min. Bur. Bull. No. 67, pp. 18, 32–36, 201, 204–209, 1914.

Eddy, L. H. 1. Quicksilver in California in 1910: Eng. and Min. Jour., vol. 91, p. 85, Jan. 7, 1911.

———2. Quicksilver in California: Mineral Industry, vol. 19, pp. 592–593, 1911.

———3. Quicksilver in California in 1911: Eng. and Min. Jour., vol. 93, p. 38, Jan. 6, 1912.

———4. Quicksilver in California: Mineral Industry, vol. 20, pp. 651–652, 1912.

———5. Quicksilver in California: Eng. and Min. Jour., vol. 95, p. 78, Jan. 11, 1913; Mineral Industry, vol. 21, pp. 744–745, 1913.

———6. Quicksilver operations in northern California: Eng. and Min. Jour., vol. 96, p. 828, Nov. 1, 1913.

———7. Quicksilver in California in 1913: Eng. and Min. Jour., vol. 97, p. 155, Jan. 10, 1914.

———8. Quicksilver in California in 1914: Eng. and Min. Jour., vol. 99, pp. 68–69, Jan. 9, 1915.

Edwards, C. E. 1. California quicksilver industry: Min. World, vol 24, pp. 270–271, Feb. 24, 1906.

Egleston, Thomas. 1. Notes on the treatment of mercury in north California: Am. Inst. Min. Eng. Trans., vol. 3, pp. 273–307, 1875.

———2. The metallurgy of silver, gold, and mercury in the United States, 2 vols., New York and London, 1887–1890.

Electrical Review and Western Electrician. 1. Oldest mercury-vapor lamp still fit for service: Vol. 70, p. 44, 1 fig., Jan. 6, 1917.

Electrical World. 1. Improved mercury-vapor lamps: Vol. 69, p. 145, illus., Jan. 20, 1917.

Emmet, W. L. R. 1. Mercury boiler; a thermodynamic process in tandem with a steam-generating plant for the production of power: Eng. Mag., vol. 47, pp. 265–268, May, 1914.

———2. Power from mercury vapor: Am. Inst. Elec. Eng. Proc., vol. 33, pp. 473–489, illus., January, 1914.

Emmons, S. F. 1. Geological distribution of the useful metals in the United States [quicksilver]: Am. Inst. Min. Eng. Trans., vol. 22, pp. 85–86, 1894.

Emmons, S. F., and Becker, G. F. 1. Statistics and technology of the precious metals; placer mines, amalgamating mills [quicksilver]: Tenth Census, vol. 13, pp. 200, 259, 264, Append. I, p. 455, 1885.

Emmons, W. H. 1. The Neglected mine and near-by properties. Durango quadrangle, Colo.: U. S. Geol. Survey Bull. 260, pp. 123–127, 1905.

———2. Exploration of metalliferous deposits [mercury]: Min. and Sci. Press, vol. 114, p. 440, Mar. 31, 1917.

———3. The enrichment of ore deposits [mercury; small replacement power of, list of principal mercury minerals, analyses, description, occurrence]: U. S. Geol. Survey Bull. 625, pp. 138–139, 392–398, 1917.

Emmons, W. H., and Calkins, F. C. 1. Geology and ore deposits of the Philipsburg quadrangle, Mont.; U. S. Geol. Survey Prof. Paper 78, p. 154, 1913.

Encyclopaedia Britannica. 1. 11th ed., vol. 18, Mexico [Mining], p. 326, 1911.

Endlich, F. M. 1. Catalogue of minerals found in Colorado [mercury]: U. S. Geol. and Geog. Survey Terr. Tenth Ann. Rept., p. 146, 1878.

Engineering. 1. The critical temperature of mercury: Vol. 100, p. 502, Nov. 12, 1915.

Engineering and Mining Journal. 1. . . . quicksilver deposits of California: Vol. 22, p. 118, Aug. 19, 1876.

———2. Purification of mercury: Vol. 46, p. 191, Sept. 8, 1888.

———3. Quicksilver mining [California]: Vol. 48, pp. 470–471, Nov. 30, 1889.

———4. Quicksilver Mining Co. [New Almaden, Santa Clara County, Cal.]: Vol. 78, pp. 676–677, Oct. 27, 1904.

———5. Quicksilver production in California: Vol. 79, p. 22, Jan. 5, 1905.

———6. Quicksilver, how it comes and how weighed in the form of amalgam: Vol. 80, p. 308, Aug. 19, 1905.

———7. How to purify mercury: Vol. 94, p. 640, Oct. 5, 1912.

———8. The trend of quicksilver metallurgy: Vol. 94, pp. 545–546, Sept. 21, 1912.

———9. California quicksilver in 1912: Vol. 95, p. 967, May 10, 1913.

———10. The quicksilver matter: Vol. 95, p. 817, Apr. 19, 1913.

———11. Quicksilver near Mina, Nev.; Vol. 96, pp. 93, 809, July 12 and Oct. 25, 1913.

———12. The quicksilver market: Vol. 97, pp. 53, 154–155, Jan. 10, 1914.

———13. Quicksilver mining in 1913: Vol. 97, p. 154, Jan. 10, 1914.

———14. Mercury recovery plant at Fresnillo, Zacatecas, Mexico: Vol. 97, pp. 953–954, illus., May 9, 1914.

———15. Some deficiencies in mineral resources: Vol. 98, p. 450, Sept. 5, 1914.

———16. Quicksilver market: Vol. 99, pp. 49, 68, 960, Jan. 9, and May 29, 1915.

———17. Cinnabar in western Nevada: Vol. 100, p. 668, October 23, 1915.

———18. Quicksilver receipts at San Francisco: Vol. 101, p. 418, Feb. 26, 1916.

———19. Production of quicksilver in California in 1915: Vol. 101, p. 508, Mar. 18, 1916.

———20. Concentrating quicksilver ores: Vol. 101, p. 1033, June 10, 1916.

———21. Oceanic quicksilver mill: Vol. 102, pp. 512–513, Sept. 16, 1916.

———22. Landers mercury furnace; Vol. 102, p. 634, Oct. 7, 1916.

———23. Robbins barrel amalgamator; Vol. 102, p. 712, Oct. 14, 1916.

———24. Discovery of cinnabar near Gold Circle district, Nev.; Vol. 102, p. 767, Oct. 21, 1916.

———25. Quicksilver; Vol. 103, p. 6, Jan. 6, 1917.

———26. Minerals of military importance [mercury]; Vol. 103, pp. 974–975, June 2, 1917.

———27. Quicksilver in California; Vol. 103, p. 1023, June 9, 1917.

Fairbanks, H. W. 1. Some remarkable hot springs and associated mineral deposits in Colusa County, Cal.: Science, vol. 23, pp. 120–121, 1894.

Fawcett, Waldon. 1. A quicksilver furnace: Am. Inventor, p. 143, November, 1905.

Feust, Arthur. 1. Modern quicksilver reduction: Min. and Sci. Press, vol. 99, p. 795, Dec. 11, 1909.

Flores, T., El mercurio en México: Boletín minero, vol. 1, No. 1, pp. 13–15, Mexico, Jan. 1, 1916.

Forbes, G. S., and Richter, H. W. 1. The measurement of oxidation potentials at mercury electrodes. The chromic-chromous potential: Am. Chem. Soc. Jour., vol. 39, pp. 1140–1148, 4 figs., June, 1917.

Forstner, William. 1. The quicksilver resources of California: California State Min. Bur. Bull. 27, 260 pp., illus., 1903.

———2. The quicksilver deposits of California: Eng. and Min. Jour., vol. 78, pp. 385–386, 426–428, illus., Sept. 8 and 15, 1904.

Freeman, H. C. 1, The La Plata Mountains [Colorado]: Am. Inst. Min. Eng. Trans., vol. 13, pp. 681–684, 1885.

Gabb, W. M. 1. Communication on the San Luis Obispo quicksilver fossils: California Acad. Nat. Sci. Proc., vol. 3, pp. 173–174, 1864.

Galeotti, H. 1. Notice sur un gîte de mercure dans le sol tertiaire récent du Gigante au Mexique: Acad. roy. sci. Bruxelles Bull., vol. 5, pp. 196–202, 1838.

Gannett, Henry. 1. Detailed topographic work; maps of the quicksilver mining districts of California: U. S. Geol. Survey Fourth Ann. Rept., pp. 4–6, 1884.

Geary, J. W. 1. A rotary furnace for roasting quicksilver ores: Min. and Sci. Press, vol. 90, p. 22, Jan. 14, 1905.

———2. The condensation of quicksilver vapors: California Jour. Tech., vol. 7, pp. 35–36, 47, February, 1906: Min. Reporter, vol. 53, pp. 392–393, Apr. 19, 1906; Min. Mag., New York, vol. 13, p. 421, 1906.

George, R. D. 1. Mercury, quicksilver, and its ores: Colorado State Geol. Survey Bull. 6, pp. 236–238, 1913.

———2. Common minerals and rocks, their occurrence and uses [mercury, quicksilver, and its ores], pp. 249–251, Denver, Colo., 1917.

Gillan, S. L. 1. Cinnabar in the Sierra Nevada: Min. and Sci. Press, vol. 114, No. 3, p. 79, Jan. 20, 1917.

Goodyear, W. A. 1. Report on an examination of the quicksilver mines of California (May, 1871): California Geol. Survey, Geology, vol. 2, Appendix, pp. 91–135, 1882.

Grout, F. E. 1. On the behavior of cold acid sulphate solutions of copper, silver, and gold, with alkaline extracts of metallic sulphides [cinnabar]: Econ. Geology, vol. 8, pp. 417, 425, 427, 1913.

Guadalupe Mining Co. of Santa Clara County, Cal. 1. 57 pp., New York, February, 1852. Pamphlet.

Hageman, Ira. 1. Quicksilver apparatus: U. S. Patent No. 970705, Sept. 20, 1910.

Hague, Arnold. 1. Chemistry of the Washoe process; chemical action of mercury and other reagents: U. S. Geol. Expl. 40th Par. Rept., vol. 3, pp. 273–293, 1870.

Halse, Edward. 1. The silver district of Tehuilotepec, State of Guerrero, Mexico: Eng. and Min. Jour., vol. 60, pp. 197–199, Aug. 31, 1895.

———2. The quicksilver mines and reduction works at Huitzuco, Guerrero, Mexico: Fed. Inst. Min. Eng. Trans., vol. 10, pp. 72–88, 354, 1896.

Hamilton, E. M. 1. Flotation for cinnabar: Min. and Sci. Press, vol. 112, p. 541, Apr. 15, 1916.

Hamilton, Fletcher. 1. Mines and mineral resources of Del Norte County, etc. [quicksilver] (chapters of State mineralogist's report, 1913–14), p. 20, California State Min. Bur., July, 1915.

———2. Mineral production for 1914 [quicksilver]: California State Min. Bur. Bull. 70, pp. 28–30, July, 1915.

———3. Production of quicksilver in California in 1915: Eng. and Min. Jour., vol. 101, p. 508, Mar. 18, 1916.

———4. Concentration of quicksilver ores in California: Min. and Eng. World, vol. 44, p. 997, May 27, 1916.

Hanks, H. G. 1. Quicksilver: [California] State Mineralogist [First] Ann. Rept., June 1, 1880–Dec. 1, 1880, pp. 26–27, 1881.

———2. Quicksilver, receipts at San Francisco, charging sluices with, loss of, retorting: [California] State Mineralogist Second Ann. Rept., Dec. 1, 1880–Oct. 1, 1882, pp. 24, 112, 116, 117, 121, 1882.

———3. Quicksilver: California State Min. Bur. Fourth Ann. Rept., pp. 328–344, 1884.

Hanks, H. G. 4. Something about quicksilver: Min. and Sci. Press, vol. 59, pp. 22–23, June 13, 1889.

———5. The properties of mercury: Min. and Sci. Press, vol. 59, pp. 142–143, Aug. 24, 1889.

Harper's New Monthly Magazine. 1. Down in the cinnabar mines; a visit to New Almaden in 1865: Vol. 31, pp. 545–560, illus., October, 1865.

Hart, T. S. 1. Notes on the Almaden mine, Cal.: Am. Jour. Sci., 2d ser., vol. 16, pp. 137–139, 1853.

Haverstock, R. S. 1. Quicksilver: Min. and Sci. Press, vol. 84, pp. 4–5, Jan. 4, 1902.

Heberlein, C. A. 1. The mining and reduction of quicksilver ore at the Oceanic mine, Cambria, Cal.: Am. Inst. Min. Eng. Trans., vol. 51, pp. 110–119, 1916.

Hess, F. L. 1. [Occurrence of cinnabar and mercury near Livermore, Cal.]: U. S. Geol. Survey Bull. 285, p. 388, 1906.

Hewitt, A. S. 1. A century of mining and metallurgy in the United States [commencement of mining in New Almaden quicksilver mine, Cal.]: Am. Inst. Min. Eng. Trans., vol. 5, pp. 175–176, 1877.

Higgins, W. C. 1. The Nevada Cinnabar Co.: Salt Lake Min. Rev., vol. 16, p. 21, Sept. 30, 1914.

Hill, B. F. 1. The Terlingua quicksilver deposits, Brewster County, Tex.: Texas Univ. Min. Survey Bull. 4, 74 pp., illus., maps, October, 1902.

———2. The occurrence of the Texas mercury minerals: Am. Jour. Sci., 4th ser., vol. 16, pp. 251–252, 1903.

———3. Das Vorkommen der texanischen Quecksilbermineralien: Zeitschr. Kryst. Min., Bd. 39, pp. 1–2, 1904.

Hill, J. M. 1. The mining districts of the western United States [quicksilver]: U. S. Geol. Survey Bull. 507, pp. 54, 77, 114, 199, 245, 262, 1912.

Hill, R. T. 1. Physical geography of the Texas region [occurrence of cinnabar]: U. S. Geol. Survey Top. Atlas (folio 3), p. 12, 1900.

———2. The cinnabar deposits of the Big Bend province of Texas: Eng. and Min. Jour., vol. 74, pp. 305–307, illus., Sept. 6, 1902.

———3. The geographic and geologic features, and their relation to the mineral products, of Mexico [cinnabar]: Am. Inst. Min. Eng. Trans., vol. 32, p. 173, 1902.

Hillebrand, W. F. 1. Preliminary announcement concerning a new mercury-mineral from Terlingua (Tex.): Science, new ser., vol. 22, p. 844, 1905.

Hillebrand, W. F., and Schaller, W. T. 1. The mercury minerals from Terlingua, Tex.: U. S. Geol. Survey Bull, 405, 174 pp., 6 pls., 1909.

Hinckley, F. C. [in Spurr, J. C.] 1. [Deposits of quicksilver ore near Kolmakof, Alaska]: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, p. 129, 1900.

Hoffmann, G. C. 1. Chemical contributions to the geology of Canada [occurrence of cinnabar in British Columbia]: Canada Geol. Survey Ann. Rept., 1886, new ser., vol. 2, p. 9 T, 1887.

———2. Chemical contributions to the geology of Canada [occurrence of native mercury in British Columbia]: Canada Geol. Survey Ann. Rept., 1890–1891, new ser., vol. 5, pt. 2, pp. 65–66 R, 1893.

———3. Chemical contributions to the geology of Canada [occurrence of cinnabar in British Columbia]: Canada Geol. Survey Ann. Rept., 1892–1893, new ser., vol. 6, p. 31 R, 1895.

Hore, R. E. 1. Occurrence of minerals in Canada [mercury or quicksilver]: Canadian Min. Manual, p. 117, 1916–1917.

Hornaday, W. D. 1. The cinnabar deposits of Terlingua, Tex.: Min. World, vol. 33, pp. 1133–1134, 5 figs., Dec. 17, 1910.

Horton, F. W. 1. Quicksilver: U. S. Geol. Survey Mineral Resources, 1905, pp. 393–404, 1906.

Hovey, E. O. 1. Ores of economic importance [mercury]: U. S. Geol. Survey Mineral Resources, 1901, p. 971, 1902.

How, Henry. 1. Mineralogy of Nova Scotia [mercury], p. 61, Halifax, N. S., 1869.

Huff, W. B. 1. The spectra of mercury: Astrophys. Jour., vol. 12, pp. 103–109, September, 1900.

Humboldt, Alexander. 1. Essai politique sur le royaume de la Nouvelle Espagne [Mexico] [mercure], vol. 2, p. 585, Paris, 1811.

Hunt, T. S. 1. Mineral species of Canada [quicksilver]: Canada Geol. Survey Fifteenth Rept. Prog., p. 518, 1863.

Hutchins, Thomas. 1. An account of the success of some attempts to freeze quicksilver at Albany Fort, in Hudson's Bay, in the year 1775: Philos. Trans., vol. 66, pp. 174–178, 1776.

———2. Experiments for ascertaining the point of mercurial congelation: Philos. Trans., vol. 73, pp. 303*–370*, pl. 7, 1783.

Imperial Institute, London. 1. The occurrence, distribution, and uses of mercury: Bull., vol. 11, No. 3, pp. 479–495, July–September, 1913.

Ingalls, W. R. 1. Work was begun at the quicksilver mines of New Almaden, Cal., 1851: Mineral Industry, vol. 1, p. 227, 1893.

Innes, Murray. 1. California quicksilver: Eng. and Min. Jour. vol. 101, p. 68, Jan. 8, 1916.

James, G. A. 1. The James apparatus for quicksilver determination: Eng. and Min. Jour., vol. 90, pp. 800–801, illus., Oct. 22, 1910.

Jameson, Robert. 1. A treatise on the external, chemical, and physical characters of minerals [fluid minerals, mercury], 1st ed., p. 81, Edinburgh, 1805; 3d ed., p. 275, Edinburgh, 1817.

Jamieson, G. S. 1. A new volumetric method for the determination of mercury: Am. Jour. Sci., 4th ser., vol. 33, pp. 349–351, 1912.

Janin, Louis, jr. 1. Mining and metallurgy of quicksilver: In Raymond, Mines and mining in the States and Territories west of the Rocky Mountains, Sixth Ann. Rept. [for 1873], pp. 379–407, 1874.

Joseph, P. E. 1. Mercury-quicksilver: Arizona State. Bur. Mines Bull. 12, 8 pp., 1916.

Juretzka, Franz. 1. Die Verarbeitung quecksilberhaltiger Nebenmaterialien im Zinkhüttenbetriebe [mercury from zinc blende]: Metall u. Erz, vol. 12, pp. 307–310, 5 figs., Aug. 8, 1915.

Kemp, J. F. 1. Ore deposits of the United States [mercury], 1st ed., pp. 267–269, 1893; 2d ed., pp. 309–312, 1895; 3d ed. ("and Canada" added to title), pp. 424–428, 1900.

———2. The rôle of the igneous rocks in the formation of veins: Am. Inst. Min. Eng. Trans., vol. 31, pp. 169–198, 1902.

King, Clarence. 1. Mining districts [geological occurrence of quicksilver]: U. S. Geol. Expl. 40th Par., vol. 3, p. 5, 1870.

Kirk, M. P. 1. The Terlingua quicksilver district: Min. Mag., New York, vol. 11, pp. 441–443, May, 1905.

Kirk, M. P., and Malcolmson, J. W. 1. A new quicksilver mining district [Big Bend, Tex.]: Eng. and Min. Jour., vol. 77, pp. 685–686, Apr. 28, 1904.

Knipp, C. T. 1. Efficient and rapid mercury still: Science, new ser., vol. 33, pp. 667–669, Apr. 28, 1911.

———2. A simple demonstration tube for exhibiting the mercury hammer, glow by mercury friction, and the vaporization of mercury at reduced pressure: School Sci. and Math., vol. 17, pp. 442–3, May, 1917.

Knopf, Adolph. 1. Some cinnabar deposits in western Nevada: U. S. Geol. Survey Bull. 620, pp. 59–68, Sept. 14, 1915; Min. American, vol. 72, p. 8, Nov. 13, 1915.

Koch, W. E. 1. Quicksilver in Texas: Mineral Industry, vol. 17, p. 745, 1909.

Kraus, C. A. 1. Mercury vapor pumps for operating against high pressure: Am. Chem. Soc. Jour., vol. 39, pp. 2183–2186, 1 fig., October, 1917.

Krusch, P. 1. Vorkommen und Entstehung der Quecksilbererze: Prometheus, Jahrg. 7, No. 340, pp. 437–440; No. 341, pp. 458–461, 1896.

Laguerenne, T. L. 1. Informe que rinde á la Secretaría de Fomento, como resultado de su exploración á los criaderos metalíferos de la Sierra del Estado de Guerrero: Mexico, Ministerio de fomento Anales, vol. 7, pp. 605–687, 1882.

Lakes, A. 1. New Almaden mines of Santa Clara County, Cal.: Mines and Minerals, vol. 19, pp. 346–349, illus., March, 1899.

Lake Quicksilver Mining Co. 1. Bear mining district, Lake County, Cal., Prospectus, 8 pp., New York, 1864. Pamphlet.

Lake Valley Quicksilver Mining Co. 1. Reports by Profs. Spence, Silversmith, Engineer Widmann, and H. Woodleaf, of San Francisco, Cal., with Profs. Adelberg and Raymond's analysis and assay of the ores, 28 pp., New York, 1865. Pamphlet.

Lamb, M. R. 1. Flotation for cinnabar: Min. and Sci. Press, vol. 113, p. 6, July 1, 1916.

Landers, W. H. 1. New Almaden quicksilver mine: Eng. and Min. Jour., vol. 100, p. 687, Oct. 23, 1915.
———2. Quicksilver mining in California: Min. and Sci. Press, vol. 112, pp. 282–284, map. Feb. 19, 1916.
———3. The smelting of mercury ores: Eng. and Min. Jour., vol. 102, pp. 630–633, Oct. 7, 1916.
Lang, Herbert. 1. Quicksilver reduction: Min. and Sci. Press, vol 112, pp. 707–714, May 13, 1916.
Langmuir, I. 1. Condensation pump; an improved form of high vacuum pump: Gen. Electric Rev., vol. 19, pp. 1060–71, December, 1916; Franklin Inst. Jour., vol. 182, pp. 719–743, December, 1916. Abstract, Sibley Jour. Eng., vol. 31, pp. 105–6, January, 1917.
Lawson, A. C. 1. Quicksilver: U. S. Geol. Survey Geol. Atlas, San Francisco folio (No. 193), p. 22, 1914.
LeConte, Joseph. 1. On mineral-vein formation now in progress at Steamboat Springs compared with the same at Sulphur Bank: Am. Jour. Sci., 3d ser., vol. 25, pp. 424–428, 1883.
———2. On the genesis of metalliferous veins: Am. Jour. Sci., 3d ser., vol. 26, pp. 1–19, 1883.
LeConte, Joseph, and Rising, W. B. 1. The phenomena of metalliferous-vein formation now in progress at Sulphur Bank, Cal.: Am. Jour. Sci., 3d ser., vol. 24, pp. 23–33, 1882.
Lindgren, Waldemar. 1. The gold-quartz veins of Nevada City and Grass Valley districts, Cal. [occurrence of cinnabar]: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 2, p. 119, 1896.
———2. The gold belt of the Blue Mountains of Oregon [cinnabar, mercurial tetrahedrite, and mercury]: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pp. 604, 642, 683, 708, 1901.
———3. Rare minerals in gold-quartz veins of eastern Oregon [cinnabar and mercurial tetrahedrite]: Min. and Sci. Press, vol 82, p. 252, June 1, 1901.
———4. The Annie Laurie mine, Piute County, Utah [occurrence of mercury]: U. S. Geol. Survey Bull. 285, p. 90, footnote, 1906.
———5. Cinnabar in decomposed granite, Steamboat Springs, Nev.: Am. Inst. Min. Eng. Trans., vol. 36, p. 30, 1906.
———6. The relation of ore deposition to physical conditions [occurrence of cinnabar]: Econ. Geology, vol. 2, pp. 114, 119, 120, 1907.
———7. Mineral deposits [cinnabar, metacinnabarite, and quicksilver], pp. 107, 441, 457–473, 800–801, 812, New York and London, 1913.
———8. Geology and mineral deposits of the National mining district, Nev. [occurrence of cinnabar]: U. S. Geol. Survey Bull. 601, pp. 14, 15, 47, 48, 1915.
Lindgren, Waldemar, and Turner, H. W. 1. Quicksilver deposits: U. S. Geol. Survey Geol. Atlas, Placerville folio (No. 3) [p. 3], 1894.
———2. Quicksilver: U. S. Geol. Survey Geol. Atlas, Smartsville folio (No. 18) [p. 6], 1895.
Lowell, F. L. 1. Quicksilver for 1910: Min. and Sci. Press, vol, 102, p. 62, Jan. 7, 1911.
———2. Mines and minerals of Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus counties [quicksilver] (chapters of State mineralogist's report, 1913–14), pp. 176, 206–207, California State Min. Bur., July, 1915.
Lyman, C. S. 1. Mines of cinnabar in upper California: Am. Jour. Sci., 2d ser., vol. 6, pp. 270–271, 1848.
Lytle, J. A. 1. Report on the Altoona quicksilver mine, Trinity County, Cal. [manuscript], 6 pp., dated Sept. 1, 1884.
McCaskey, H. D. 1. Quicksilver: U. S. Geol. Survey Mineral Resources, 1907, pt. 1, pp. 677–692, 1908. [Pages 689–692 contain a bibliography on quicksilver.]
——— 2. Quicksilver: U. S. Geol. Survey Mineral Resources, 1908, pt. 1, pp. 683–695, 1909.
———3. The New Idria quicksilver mine, Cal.: Min. World, vol. 32, p. 104, Jan. 15, 1910.
———4. Quicksilver: U. S. Geol. Survey Mineral Resources, 1909, pt. 1, pp. 549–559, 1911.
———5. Quicksilver: U. S. Geol. Survey Mineral Resources, 1910, pt. 1, pp. 693–710, 1911.

McCaskey, H. D. 6. Quicksilver: U. S. Geol. Survey Mineral Resources, 1911, pt. 1, pp. 889–921, 1912.

——— 7. Quicksilver deposits: Min. Sci., vol. 66, pp. 41–42, July 18, 1912.

——— 8. Widespread deposits of cinnabar in Nevada: Min. Sci., vol. 66, pp. 55–57, July 25, 1912.

——— 9. Quicksilver: U. S. Geol. Survey Mineral Resources, 1912, pt. 1, pp. 931–948, 1913.

——— 10. The quicksilver situation: Eng. and Min. Jour., vol. 98, p. 647, Oct. 10, 1914.

——— 11. Quicksilver; U. S. Geol. Survey Mineral Resources, 1913, pt. 1, pp. 197–212, 1914.

——— 12. Quicksilver: U. S. Geol. Survey Mineral Resources, 1914, pt. 1, pp. *13, *29, 315–332, 1916.

——— 13. Quicksilver: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, pp. 259–277, 1916.

McGarrahan, William. 1. [*See* Panoche Grande Quicksilver Mining Co. for history of case, 1861, and C. P. Shaw, 1872. *See also* Panoche Grande rancho, Cal., speech of James A. Garfield, February 20, 1871.]

——— 2. The history of the McGarrahan claim as written by himself, extracts from letters, papers, and documents of said McGarrahan, 411 pp., Washington 1876 (?).

McLeish, John. 1. Mineral production of Canada during the calendar years 1907 and 1908 [mercury]: Canada Dept. Mines, Mines Branch Ann. Rept., p. 146, Ottawa, 1910.

——— 2. Mineral production of Canada during the calendar year 1909 [mercury]: Canada Dept. Mines, Mines Branch Ann. Rept., p. 138, Ottawa, 1911.

——— 3. Mineral production of Canada during the calendar year 1911 [mercury]: Canada Dept. Mines, Mines Branch Ann. Rept., p. 151, Ottawa, 1913.

——— 4. Mineral production of Canada during the calendar year 1912 [mercury]: Canada Dept. Mines, Mines Branch Ann. Rept., p. 161, Ottawa, 1914.

——— 5. Mineral production of Canada during the calendar year 1913 [mercury]: Canada Dept. Mines, Mines Branch Ann. Rept., p. 149, Ottawa, 1914.

——— 6. Mineral Production of Canada during the calendar year 1915 [mercury]: Canada Dept. Mines, Mines Branch Ann. Rept., p. 149, 1917.

McLennan, J. C. 1. On the temperature of the mercury arc: Sci. Am. Suppl., vol. 79, p. 107, Feb. 13, 1915.

McNeely, W. M. 1. Notes on quicksilver: Mexican Min. Jour., vol. 8, p. 24, Sept., 1909.

Mactear, James. 1. Mining and metallurgy of quicksilver in Mexico: Inst. Min. and Met., London, vol. 4, pp. 69–120, 1896.

Mallet, J. W. 1. Note on the extent to which mercury volatilizes along with the vapor of water at 100° C.: Am. Jour. Sci., 2d ser., vol. 30, pp. 124–125, 1860.

Manufacturers Record. 1. American quicksilver industry as affected by the war: Vol. 71, p. 61, Jan. 11, 1917.

Map of Alaska. 1. Distribution of mineral deposits [quicksilver]: U. S. Geol. Survey Bull. 642, pl. 1, in pocket, 1916.

Mason, R. B. 1. Letter from Monterey, Cal., dated Aug. 17, 1848: Repts. Secretary of War (H. Doc. 17, 31st Cong., 1st sess.), pp. 528–536, 1850. Gives a description of the quicksilver mines near San Jose.

Mellor, J. W. 1. Modern inorganic chemistry [mercury], new ed., pp. 341–345, London, 1917.

Melville, W. H. 1. Metacinnabarite from New Almaden, Cal.: Am. Jour. Sci., 3d ser., vol. 40, pp. 291–295, 1890: U. S. Geol. Survey Bull. 78, pp. 80–83, 1891.

Melville, W. H., and Lindgren, Waldemar. 1. Contributions to the mineralogy of the Pacific coast [cinnabar crystals]: U. S. Geol. Survey Bull. 61, pp. 11–22, 1890.

Merrill, F. J. H. 1. The mercury deposits of Mexico. Min. World, vol. 24, p. 244, Feb. 17, 1906.

Merritt, W. H. 1. Occurrence of cinnabar in British Columbia: Fed. Inst. Min. Eng. Trans., vol. 13, pp. 592–594, 3 figs., 1898.

Mertie, J. B., jr., and Harrington, G. L. 1. Mineral resources of the Ruby-Kuskokwim region [quicksilver lodes]: U. S. Geol. Survey Bull. 642, pp. 237–238, 258–259, 263, 1916.

Metallgesellschaft. 1. Comparative statement of the production of quicksilver: Thirteenth Ann. issue, pp. 19, 102, April, 1907.

———2. Comparative statement of the production of quicksilver: Fourteenth Ann. issue, pp. 19, 102, Mar., 1908.

———3. Comparative statement of the production of quicksilver: Fifteenth Ann. issue, pp. 19, 102, July, 1909.

———4. Comparative statement of the production of quicksilver: Sixteenth Ann. issue, pp. 19, 102, June, 1910.

———5. Comparative statement of the production of quicksilver: Seventeenth Ann. issue, pp. 19, 98, July, 1911.

———6. Comparative statement of the production of quicksilver: Eighteenth Ann. issue, pp. 19, 98, July, 1912.

———7. Comparative statement of the production of quicksilver: Nineteenth Ann. issue, pp. 19, 100, July, 1913.

———8. Comparative statement of the production of quicksilver: Twentieth Ann. issue, pp. 19, 100, July, 1914.

Metallurgical and Chemical Engineering. 1. Roasting furnace with fume condenser [designed to operate on ores containing volatile metals such as quicksilver and zinc]: Vol. 16, p. 706, patent, fig. 3 [diagram], June 15, 1917.

Mexican Mining Journal. 1. Purification of mercury: Vol. 11, pp. 32–33, Sept., 1910.

———2. Assaying mercury ores: Vol. 14, p. 30, Feb., 1912.

Miller, W. G. 1. Notes on the Cobalt area [Ontario] [mercury]: Eng. and Min. Jour., vol. 92, p. 647, Sept. 30, 1911.

Mineral Industry. 1. Quicksilver: Vol. 1, pp. 4–10, 407–410, 1893.

———2. Quicksilver: Vol. 2, pp. 551–554, 793, 799, 803, 1894.

———3. Quicksilver: Vol. 3, pp. 477–481, 1895.

———4. Quicksilver: Vol. 4, pp. 519–523, 1896.

———5. Quicksilver: Vol. 5, pp. 4, 7, 461–465, 828, 1897.

———6. Quicksilver: Vol. 6, pp. 4, 5, 563–565, 800, 831–832, 853, 856, 1898.

———7. Quicksilver: Vol. 7, pp. 3, 5, 577–581, 871, 874, 1899.

———8. Quicksilver: Vol. 8, pp. 3, 5, 8, 487–491, 856, 877, 880, 1900.

———9. Quicksilver: Vol. 9, pp. 3, 563–566, 804, 858, 879, 882, 1901.

———10. Quicksilver: Vol. 10, pp. 3, 555, 557, 784, 826–830, 858, 879, 882, 1902.

———11. Quicksilver: Vol. 11, pp. 3, 5, 776, 800, 831–832, 853, 856, 1903.

———12. Quicksilver: Vol. 12, pp. 3, 4, 305, 309, 311, 1904.

———13. Quicksilver: Vol. 13, pp. 3, 4, 371–375, 543, 1905.

———14. Quicksilver: Vol. 14, pp. 502–503, 1906.

———15. Quicksilver: Vol. 15, pp. 3, 9, 674–675, 676–679, 928, 1907.

———16. Quicksilver: Vol. 16, pp. 813, 816–817, 818–820, 1908.

———17. Quicksilver: Vol. 17, p. 13, 1909.

———18. Quicksilver: Vol. 18, pp. 3, 615–617, 1910.

———19. Quicksilver: Vol. 19, pp. 590–596, 1911.

———20. Quicksilver: Vol. 20, pp. 650–653, 1912.

———21. Quicksilver: Vol. 21, pp. 743–749, 1913.

———22. Quicksilver: Vol. 22, p. 994, 1914.

Mining American. 1. A new cinnabar district [Nevada]: Vol. 73, p. 7, Mar. 18, 1916.

———2. The mercury situation: Vol. 73, p. 5, Mar. 25, 1916.

———3. California's quicksilver: Vol. 75, p. 7, July 28, 1917.

Mining and Engineering Review (San Francisco). 1. Metallurgy of quicksilver: Vol. 20, pp. 7–8, Mar. 4, 1905.

———2. Quicksilver production in California: Vol. 20, p. 5, Jan. 28, 1905.

Mining and Engineering World. 1. Mexican quicksilver mining operations: Vol. 37, p. 282, Aug. 17, 1912.

———2. The world's quicksilver industry in 1912: Vol. 28, pp. 160–161, 904, Jan. 25 and May 10, 1913.

———3. Quicksilver output in 1913; California, largest producer: Vol. 41, p. 254, Aug. 8, 1914.

———4. Quicksilver deposits of the Kuskokwim region, Alaska: Vol. 42, pp. 817–819, May 1, 1915.

———5. Quicksilver deposits on the Mazatzal Range of Arizona: Vol. 44, pp. 81–82, Jan. 8; p. 1,131, June 17, 1916.

———6. The reaction in quicksilver: Vol. 44, p. 794, Apr. 22, 1916.

Mining and Engineering World. 7. Concentration methods for the reduction of quicksilver ores: Vol. 45, p. 366, Aug. 26, 1916.
———8. Recovering quicksilver from ores: Vol. 45, p. 740, Oct. 28, 1916.
———9. Quicksilver mining at Idria, Cal.: Vol. 45, p. 1112, Dec. 30, 1916.
Mining and Scientific Press. 1. Sonoma County quicksilver mines [California]: Vol. 27, p. 166, Sept. 13, 1873.
———2. Divisibility of quicksilver, gold, and silver: Vol. 28, p. 22, Jan. 10, 1874.
———3. California quicksilver in 1871, 1872, and 1873: Vol. 28, p. 50, Jan. 24, 1874.
———4. Why quicksilver is high [contains table of production at New Almaden, Cal., for 21 years]: Vol. 28, p. 184, Mar. 21, 1874.
———5. Quicksilver discoveries in California: Vol. 28, pp. 98, 118, 154, 170, 312, 1874.
———6. Quicksilver in California: Vol. 28, pp. 186, 198, 214, 258, 290, 294, 310, 314, 316, 322, 326, 337, 358, 362, 370, 402, 410, 1874.
———7. The Rattlesnake quicksilver mine [California]: Vol. 29, p. 54, July 25, 1874.
———8. Mineral wealth of Colusa County [cinnabar]: Vol. 29, p. 70, Aug. 1, 1874.
———9. From the quicksilver mines [California]: Vol. 29, p. 81, Aug. 8, 1874.
———10. Quicksilver in San Luis Obispo County (condensed from San Luis Obispo Tribune of Aug. 1, 1874): Vol. 29, p. 102, Aug. 15, 1874.
———11. Quicksilver in Sonoma and Napa [condensed from Calistoga Press]: Vol. 29, p. 114, Aug. 22, 1874.
———12. The Pine Flat quicksilver mines [California]: Vol. 29, pp. 139, 154, 322, Aug. 29, Sept. 5, and Nov. 21, 1874.
———13. Cinnabar, Lake, and Calistoga districts [California]: Vol. 29, p. 218, Oct. 3, 1874.
———14. Purifying quicksilver: Vol. 29, p. 289, Nov. 7, 1874.
———15. The Colusa quicksilver mines: Vol. 30, pp. 33, 42, 82, Jan. 16 and Feb. 6, 1875.
———16. Sonoma County quicksilver mines: Vol. 30, p. 66, Jan. 30, 1875.
———17. California [quicksilver and cinnabar]: Vol. 30, pp. 132–133, Feb. 27, 1875.
———18. Quicksilver in Solano County: Vol. 30, pp. 146, 346, Mar. 6 and May 29, 1875.
———19. Reduction of quicksilver ores—Patera's process: Vol. 30, p. 241, illus., Apr. 10, 1875.
———20. Mercurial minerals and their associates: Vol. 59, pp. 298–299, 318–319, Oct. 19 and 26, 1889.
———21. California quicksilver mines: Vol. 81, pp. 506–507, Nov. 3, 1900.
———22. The Great Eastern quicksilver mine [Sonoma County, Cal.]: Vol. 89, p. 391, 2 figs., Dec. 10, 1904.
———23. Cinnabar in San Luis Obispo County, Cal.: Vol. 89, p. 323, 2 figs., Nov. 12, 1904.
———24. Reduction of cinnabar at Sulphur Creek, Cal.: Vol. 90, p. 335, May 27, 1905.
———25. Reduction of quicksilver: Vol. 95, p. 151, Aug. 3, 1907.
———26. The use and care of mercury: Vol. 95, pp. 216–217, Aug. 17, 1907.
———27. [Quicksilver near Las Penas, Mexico]: Vol. 95, p. 732, Dec. 14, 1907.
———28. Quicksilver in California: Vol. 100, pp. 15–16, map, Jan. 1, 1910.
———29. The quicksilver situation: Vol. 100, p. 789, May 28, 1910.
———30. Quicksilver in Mexico: Vol. 102, pp. 820–821, June 17, 1911.
———31. Quicksilver [editorial]: Vol. 104, pp. 298–299, Feb. 24, 1912.
———32. Report from the Terlingua quicksilver district, Tex.: Vol. 105, p. 772, Dec. 14, 1912.
———33. Cinnabar in Washington: Vol. 106, p. 796, May 24, 1913.
———34. Recovery of quicksilver from ores: Vol. 107, p. 348, Aug. 30, 1913.
———35. Discovery of cinnabar in Matzatzal Mountains, Ariz.: Vol. 109, p. 156, July 25, 1914.
———36. Notes on quicksilver in California: Vol. 112, p. 353, Mar. 4, 1916.
———37. Quicksilver from alluvial deposits, Oregon [editorial]: Vol. 112, p. 497, Apr. 1, 1916.
———38. Quicksilver [editorial]: Vol. 112, p. 659, May 6, 1916.
———39. Concentration of quicksilver ores: Vol. 112, p. 796, May 27, 1916.

Mining and Scientific Press. 40. The demand for quicksilver: Vol. 113, p. 137, July 22, 1916.

———41. Mineral production of California in 1915: Vol. 113, p. 361, Sept. 2, 1916.

———42. Metal market in 1916 [quicksilver]: Vol. 114, pp. 6–7, Jan. 6, 1917.

———43. Freezing point of mercury: Vol. 114, p. 58, Jan. 13, 1917.

———44. Large production and extension of operation in Terlingua district, Tex.: Vol. 114, p. 590, Apr. 28, 1917.

———45. New metallurgical methods for quicksilver ores: Vol. 114, p. 768, June 2, 1917.

Mining and Statistic Magazine (New York) [continuation of Mining Magazine, New York]. 1. Mercury mines of New Almaden, Cal.: Vol. 10, pp. 142–143, 1858.

———2. Quicksilver mines of Monterey County, Cal.: Vol. 10, pp. 246–247, 1858.

———3. Santa Clara quicksilver mines [Cal.]: Vol. 10, p. 246, 1858.

———4. The quicksilver mine of New Almaden [Cal.]: Vol. 10, pp. 448–449, 1858.

Mining Journal (London). 1. Concentration of quicksilver ores: Vol. 118, pp. 503–504, Aug. 11, 1917.

Mining Magazine (New York). 1. The Almaden [quicksilver] mine, Cal.: Vol. 1, pp. 209–210, 1853.

———2. Quicksilver in California: Vol. 2, pp. 116–117, 1854.

———3. Quicksilver exported from San Francisco during the year 1853: Vol. 2, pp. 352–353, 1854.

———4. Quicksilver: Vol. 7, p. 424, 1856.

———5. Shipment of quicksilver from San Francisco: Vol. 8, p. 104, 1857.

———6. Quicksilver: Vol. 9, pp. 99–101, 1857.

Mining Magazine (New York) [not a continuation of the previous Mining Magazine of New York]. 1. Quicksilver in Utah [editorial]: Vol. 12, pp. 125–126, 1905.

Mining Magazine and Journal of Geology [continuation of Mining and Statistic Magazine]. 1. New quicksilver mine in California: Second ser., vol. 1, p. 81, November, 1859.

Mining Reporter. 1. Texas quicksilver deposits: Vol. 43, p. 155, 1901.

———2. Mercury deposits of Mexico: Vol. 53, pp. 466–467, May 10, 1906.

Mining Science. 1. Methods of quicksilver reduction: Vol. 58, p. 467, Dec. 10, 1908.

———2. Quicksilver in California: Vol. 65, p. 349, Apr. 18, 1912.

———3. Large quicksilver consumption: Vol. 65, p. 525, June 20, 1912.

———4. Prospecting for quicksilver: Vol. 66, pp. 33–34, July 18, 1912.

———5. California quicksilver: Vol. 66, p. 35, July 18, 1912.

Mitchell, G. J. 1. Minerals of Oregon (cinnabar): Oregon Univ. Bull., new ser., vol. 13, pp. 20–21, November, 1915.

Monckton, G. F. 1. Cinnabar-bearing rocks of British Columbia: Inst. Min. Eng. [England] Trans., vol. 27, pp. 463–469, 1904.

Moore, G. E. 1. On the occurrence in nature of amorphous mercuric sulphide [names metacinnabar as a new species]: Am. Jour. Sci., 3d ser., vol. 3, pp. 36–43, 1872.

Moses, A. J. 1. Eglestonite, terlinguaite, and montroydite, new mercury minerals from Terlingua, Tex.: Am. Jour. Sci., 4th ser., vol. 16, pp. 253–263, 6 figs., September, 1903.

———2. Eglestonit, Terlinguait und Montroydit, neue Quecksilbermineralien von Terlingua in Texas: Zeitschr. Kryst. Min., Bd. 39, pp. 3–13, 6 figs., 1904.

Moses, A. J., and Parsons, C. L. 1. Elements of mineralogy, etc. [mercury or quicksilver minerals], 5th ed., pp. 373–378, New York, D. Van Nostrand Co., 1916.

Mosher, D. 1. Notes on the metallurgy of cinnabar ores: Pacific Miner, February, 1910. [Not seen.]

Mulholland, C. A. 1. Treatment of low-grade cinnabar ores: Australian Min. Standard, vol. 45, p. 565, June 8, 1911.

———2. The treatment of low-grade cinnabar ores: Min. and Eng. World, vol. 35, pp. 241–242, Aug. 5, 1911.

———3. Wet method of mercury extraction: Min. and Sci. Press, vol. 111, p. 346, Sept. 4, 1915.

Murray, B. L. 1. Electrolytic determination of mercury in mercury oleates: Jour. Ind. and Eng. Chemistry, vol. 8, p. 257, March, 1916.

——— 2. Electrolytic determination of mercury in mercury salicylates: Jour. Ind. and Eng. Chemistry, vol. 8, p. 258, March, 1916.

New Almaden [quicksilver] mine [of California]. 1. The discussion reviewed: Press of the Daily National office, 76 pp., San Francisco, 1859. Pamphlet.

——— 2. Further correspondence between the counsel for the proprietors and the Government, 42 pp., Washington, 1859. Pamphlet.

——— 3. Letter of Hon. John A. Collier in reference to the New Almaden quicksilver property, 29 pp., New York, 1859. Pamphlet.

——— 4. Opinion of the Court, delivered by Mr. Justice Clifford in "U. S. vs. Castillero," 53 pp., New York, 1863. Pamphlet.

——— 5. Memorial of the quicksilver miners of California, 32 pp., Washington, 1883. Pamphlet.

New Idria Mining Co., Cal. 1. *See also* McGarrahan, William, 1876, and Shaw, C. P., 1872.

Newcomb, B. M. 1. Quicksilver in California: Mineral Industry, vol. 10, pp. 555–557, 1902.

Newland, D. H. 1. Quicksilver: Mineral Industry, vol. 12, pp. 305–309, 311, 1904.

Newman, John. 1. On a new mercurio-pneumatic apparatus: Jour. Sci. and Arts, vol. 1, pp. 185–187, London, 1816.

Nöggerath, Adalbert. 1. Mittheilungen über die Quecksilbergwerke zu Almadén und Almadenejos in Spanien nebst einem Ueberblick der Vorkommnisse von Quecksilber im Allgemeinen [California, United States, Mexico]: Zeitschr. Berg., Hütten- u. Salinenwesen preuss. St., vol. 10, pp. 380, 390, 1862.

Northey, G. V. 1. Concentration of cinnabar ores: Eng. and Min. Jour., vol. 96, pp. 783–784, Oct. 25, 1913.

Ontario Bureau of Mines. 1. Cinnabar or sulphide of mercury, found in British Columbia, at the Ebenezer mine, Kicking Horse Pass, disseminated through crystalline limestone: Sixth Rept., 1896, p. 211, 1897.

——— 2. Mercury in Cobalt ores: Twenty-sixth Ann. Rept., p. 20, 1917.

Oregon Bureau of Mines and Geology. 1. Minerals and mineral industries of Oregon (quicksilver): Panama-Pacific ed., pp. 24–25, 1915.

Osmont, V. C. 1. A geological section of the Coast Ranges north of the Bay of San Francisco [quicksilver deposits]: California Univ. Dept. Geology Bull., vol. 4, pp. 50–51, Dec. 1, 1904.

Oswald, Wilhelm. 1. The principles of inorganic chemistry [mercury]: Trans. by A. Findlay, pp. 656–672, London, 1902.

Pagliucci, F. D. 1. The quicksilver deposits of Huitzuco [Mexico]: Eng. and Min. Jour., vol. 79, pp. 417–418, 2 figs., Mar. 2, 1905.

Palmer, L. A. 1. Ore occurrence at the Cloverdale mine [Sonoma County, Cal.] [quicksilver]: Min. and Sci. Press, vol. 108, p. 812, 1 fig., May 16, 1914.

Panoche Grande Quicksilver Mining Co. 1. The origin of the grant and the change of title vesting the rancho in said company, 16 pp., 1861. Pamphlet.

Panoche Grande rancho, Cal. 1. Speech of James A. Garfield on the McGarrahan claim, delivered in the House of Representatives, Feb. 20, 1871, 16 pp., 1871. Pamphlet..

Pardee, J. T., and Hewett, D. F. 1. Geology and mineral resources of the Sumpter quadrangle [mercury and cinnabar]: Oregon Bur. Mines and Geology, Mineral Resources of Oregon, vol. 1, pp. 66, 91, October, 1914.

Parker, E. W. 1. Quicksilver; summary, production, prices: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 6, pp. 7, 273–283, 1901.

——— 2. Quicksilver: U. S. Geol. Survey Mineral Resources, 1911, pt. 1, pp. 94, 110, 1912.

——— 3. Quicksilver: U. S. Geol. Survey Mineral Resources, 1912, pt. 1, pp. 117, 136, 1913.

Parks, H. M. 1. Mining increasing in Oregon [quicksilver in southwestern Oregon]: Eng. and Min. Jour., vol. 103, p. 106, Jan. 13, 1917.

Parks, H. M., and Swartley, A. M. 1. Handbook of the mining industry of Oregon [cinnabar deposits]: Oregon Bur. Mines and Geology, Mineral Resources of Oregon, vol. 2, pp. 14, 33, 55–56, 218, 227, December, 1916.

Patten, H. E., and Mains, G. H. 1. An apparatus for the purification of mercury: Jour. Ind. and Eng. Chemistry, vol. 9, pp. 600–603, June, 1917.

Penfield, S. J. 1. Crystallized tiemannite and metacinnabarite: Am. Jour. Sci., 3d ser., vol. 29, pp. 449–454, 1885.

Phillips, J. A. 1. A treatise on ore deposits [quicksilver], pp. 69, 558–561, 583, illus., London, 1884.

Phillips, J. A., and Louis, Henry. 1. A treatise on ore deposits [mercury], 2d ed., pp. 116, 117, 135, 142, 746, 791–796, 829, 830, 867, illus., London, 1896.

Phillips, W. B. 1. Sulphur, oil, and quicksilver in Trans-Pecos Texas: Texas Univ. Min. Survey Bull. 2, 42 pp., illus., map, 1902.

———2. [Description of the mapping of the quicksilver district in Texas]: Texas Univ. Min. Survey Bull. 7, pp. 8–9, map, 1904.

———3. A new quicksilver field in Brewster County, Tex.: Eng. and Min. Jour., vol. 77, pp. 160–161, Jan. 28, 1904.

———4. Extension of the quicksilver district in Brewster County, Tex.: Eng. and Min. Jour., vol. 78, p. 212, Aug. 11, 1904.

———5. Condition of the quicksilver industry in Brewster County, Tex.: Eng. and Min. Jour., vol. 78, pp. 553–554, Oct. 6, 1904.

———6. The quicksilver deposits of Brewster County, Tex.: Econ. Geology, vol. 1, pp. 155–162, 1905.

———7. Terlingua quicksilver district, Brewster County, Tex.: Min. World, vol. 23, pp. 39, 63, 95, 198, 259–260, 1905.

———8. Condition of the quicksilver industry in Brewster County, Tex.: Mineral Industry, vol. 13, pp. 376–379, 1905.

———9. Quicksilver deposits of Terlingua district, Brewster County, Tex.: Am. Min. Cong., Eighth Ann. Sess., pp. 184–193, 1906.

———10. The quicksilver deposits of Brewster County, Tex.: Econ. Geology, vol. 1, pp. 155–162, 1906.

———11. The quicksilver industry in Brewster County, Tex.: Mineral Industry, vol. 14, pp. 506–511, 1906.

———12. Prospects of the quicksilver industry in Texas: Min. World, vol. 25, p. 463, Oct. 13, 1906.

———13. Geology of quicksilver deposits: Min. World, vol. 29, p. 131, July 25, 1908.

———14. Condition of the quicksilver industry in Texas: Eng. and Min. Jour., vol. 88, pp. 1022–1024, Nov. 20, 1909.

——— 15. The mineral resources of Texas [quicksilver]: Texas Dept. Agr. Bull. 14, pp. 8, 20–21, 1910.

———16. The quicksilver industry in Texas: Eng. and Min. Jour., vol. 91, pp. 85–86, 419, Jan. 7 and Feb. 25, 1911.

———17. Quicksilver in Texas: Mineral Industry, vol. 19, pp. 593–594, 1911.

———18. Quicksilver in Texas: Mineral Industry, vol. 20, pp. 652–653, 1912.

———19. Quicksilver in Texas in 1911: Eng. and Min. Jour., vol. 93, pp. 38–39, Jan. 6, 1912.

———20. Quicksilver industry of Texas: Eng. and Min. Jour., vol. 95, pp. 78–79, Jan. 11, 1913.

———21. Quicksilver in Texas: Mineral Industry, vol. 21, pp. 746–747, 1913.

———22. Quicksilver in Texas in 1913: Eng. and Min. Jour., vol. 97, p. 156, Jan. 10, 1914.

———23. The mineral resources of Texas [quicksilver]: Texas Univ. Bull. 365 (sci. ser. No. 29), pp. 32–33, Oct. 15, 1914.

———24. Quicksilver industry of Texas: Min. and Sci. Press, vol. 115, p. 93, July 21, 1917.

Pickering, A. H. 1. Quicksilver in 1915: Min. Jour. (London), vol. 112, p. 47, Jan. 15, 1916.

Pitaval, R., and Ganet, I. 1. Traité général de commerce des minérais et métaux combustibles, alliages, engrais, etc. [mercure], pp. 568–572, Paris [1917?].

Place, R. G. 1. New Almaden quicksilver mine: Eng. and Min. Jour., vol. 100, p. 465, Sept. 18, 1915.

Pošepný, Franz. 1. The genesis of ore deposits [quicksilver]: Am. Inst. Min. Eng. Trans., vol. 23, pp. 225–226, 257, 1894; discussion, vol. 24, p. 984, 1895.

———2. The genesis of ore deposits [quicksilver], reprinted from vols. 23 and 24 of Am. Inst. Min. Eng. Trans., 2d ed., pp. 32–36, 66, 256, New York, 1902.

Powell, J. W. 1. Investigations of quicksilver deposits [in eastern California and western Nevada]: U. S. Geol. Survey Seventh Ann. Rept., pp. 25–26, 1888.

Powell, J. W. 2. Value of quicksilver at San Francisco: U. S. Geol. Survey Eighth Ann. Rept., pt. 1, p. 85, 1889.

———3. Value of quicksilver at San Francisco: U. S. Geol. Survey Tenth Ann. Rept., pt. 1, p. 52, 1890.

———4. Value of quicksilver at San Francisco: U. S. Geol. Survey Twelfth Ann. Rept., pt. 1, p. 14, 1891.

———5. Metallic products of the United States in 1893 [quicksilver]: U. S. Geol. Survey Fifteenth Ann. Rept., p. 72, 1895.

Prather, J. K. 1. Mining quicksilver; metallurgy of cinnabar: El Paso Min. Jour., 1 p., October, 1909. [Not seen.]

Prindle, L. M. 1. The Fortymile quadrangle, Yukon-Tanana region, Alaska [cinnabar associated with gold]: U. S. Geol. Survey Bull. 375, p. 32, 1909.

Purnell, Samuel. 1. Remarks on quicksilver: Min. and Sci. Press, vol. 33, pp. 240, 276, 289, 321, 352, Oct. 7, 21, and 28, Nov. 11 and 25, 1876.

Quicksilver Mining Co. [deposits in California]. 1. Charter and by-laws: Ann. Meeting Stockholders (Philadelphia), Rept., 30 pp., Jan. 4, 1864. Pamphlet.

———2. Annual report, 103 pp., Feb. 22, 1865. Pamphlet.

———3. Annual Meeting Stockholders (Philadelphia), Feb. 28, 1866: Ann. Rept., 41 pp., New York, March, 1866. Pamphlet.

———4. Annual report, 30 pp., Feb. 24, 1869. Pamphlet.

———5. Reports and exhibits at Ann. Meeting Stockholders (New York), Feb. 22, 1871. Pamphlet.

———6. Reports and exhibits at Ann. Meeting Stockholders (New York), Feb. 28, 1872. Pamphlet.

———7. Reports and exhibits at Ann. Meeting Stockholders (New York), Feb. 26, 1873. Pamphlet.

———8. Tables and tabular statements submitted at Ann. Meeting Stockholders (New York), Feb. 28, 1877; Ann. Rept. for 1876, 67 pp., New York, 1877. Pamphlet.

———9. Annual report for 1882, 63 pp., New York, 1883. Pamphlet.

———10. Report for 1883 and the four months ending Apr. 30, 1884, 84 pp., New York, 1884. Pamphlet.

———11. Report for year ending Apr. 30, 1885, 36 pp., New York, 1885. Pamphlet.

———12. Report for year ending Apr. 30, 1886, 41 pp., New York, 1886. Pamphlet.

———13. Report for year ending Apr. 30, 1887, 45 pp., New York, 1887, Pamphlet.

———14. Report for year ending Apr. 30, 1888, 51 pp., New York, 1888. Pamphlet.

———15. Report for year ending Apr. 30, 1889, 55 pp., New York, 1889. Pamphlet.

———16. Report for year ending Apr. 30, 1890, 57 pp., New York, 1890. Pamphlet.

———17. Report for year ending Apr. 30, 1891, 53 pp., New York, 1891. Pamphlet.

Ramírez, Santiago. 1. Informe sobre el mineral de Guadalcázar en el Estado de San Luis Potosí [minas de mercurio]: Mexico, Ministerio de fomento, Anales, vol. 3, pp. 395–397, 1877.

———2. Noticia histórica de la riqueza minera de Mexico [mercurio]: pp. 88–98, Mexico, Oficina tipográfica, Sec. Fomento, 1884.

Randol, J. B. 1. Production of quicksilver at New Almaden for twenty-two years and three months: Min. and Sci. Press, vol. 30, p. 72, Jan. 30, 1875.

———2. Quicksilver in California: In Raymond, Mines and mining in the States and Territories west of the Rocky Mountains, Eighth Ann. Rept. [for 1875], pp. 4–21, 1877.

———3. Production and price of quicksilver for thirty-four years, 1850 to 1883, Table, San Francisco, March, 1884. [1 sheet.]

———4. Production of quicksilver in California for the years 1885 and 1886: California State Min. Bur. Sixth Ann. Rept., pt. 1, pp. 72–73, 1886.

———5. California quicksilver, a table showing the production for the past six years, 13 pp., San Francisco, 1890. Pamphlet.

———6. Quicksilver mines and reduction works: California State Min. Bur. Tenth Ann. Rept., pp. 920–929, 1890.

———7. Quicksilver and the tariff in the House of Representatives and elsewhere, 20 pp., San Francisco, 1890. Pamphlet.

Randol, J. B. 8. Earnings and expenses of the Quicksilver Mining Co., New Almaden, Cal., for twenty-one years, from Jan. 1, 1871, to Dec. 31, 1891. Pamphlet without place of publication or date.

———9. Report on mineral industries in the United States; Quicksilver: Eleventh Census, 1890, pp. 179–245, 1892.

Rangel, Manuel. 1. Apuntes sobre la distribución de minerales en el Estado de Durango [mercurio]: Soc. Geol. Mexicana Bol., t. 7, pt. 2, p. 113, 1911.

Ransome, F. L. 1. Quicksilver [in California]: U. S. Geol. Survey Geol. Atlas, Mother Lode District folio (No. 63), p. 10, 1909.

———2. Preliminary account of Goldfield, Bullfrog, and other mining districts in southern Nevada [cinnabar]: U. S. Geol. Survey Bull. 303, p. 36, 1907.

———3. Notes on some mining districts in Humboldt County, Nev. [occurrence and character of cinnabar]: U. S. Geol. Survey Bull. 414, pp. 30, 37, 45, 65, 71, 1909.

———4. The geology and ore deposits of Goldfield, Nev. [occurrence of cinnabar]: U. S. Geol. Survey Prof. Paper 66, pp. 108, 113, 1909.

———5. Notes on some mining districts in Humboldt County, Nev. [occurrence and character of quicksilver-antimony deposits]: U. S. Geol. Survey Bull. 414, p. 71, 1909.

———6. Quicksilver deposits of the Mazatzal Range, Ariz.: U. S. Geol. Survey Bull. 620, pp. 111–128, 5 figs., 1915.

Rath, G. vom. 1. Vorträge und Mittheilungen; Bericht über die Umgebungen von San Francisco, Santa Cruz, and New Almaden, Californien: Niederrhenisch. Ges. f. Natur-und Heilkunde in Bonn, Sitzungsb., Naturwiss. Sect., 16 November, pp. 303–317, 1885.

Raymond, Rossiter W. 1. New Almaden quicksilver mines: Mineral resources of the States and Territories west of the Rocky Mountains [for 1868], pp. 9–11, 1869.

———2. Production of quicksilver during 1869: Mines and mining in the States and Territories west of the Rocky Mountains [for 1869], p. 759, 1870.

———3. Condition of the mining industry [quicksilver in California]: Mines and mining in the States and Territories west of the Rocky Mountains [for 1870], pp. 15, 29, 528, 1872.

———4. Chemistry of the Washoe process; chemical action of mercury and other reagents: Mines and mining in the States and Territories west of the Rocky Mountains [for 1870], pp. 404–405, 413, 414, 1872.

———5. Quicksilver, production and reports of: Mines and mining in the States and Territories west of the Rocky Mountains, Fourth Ann. Rept. [for 1871], p. 523, 1873.

———6. Quicksilver: Mines and mining in the States and Territories west of the Rocky Mountains, Fifth Ann. Rept. [for 1872], pp. 9, 497, 1873.

———7. Condition of the mining industry [quicksilver in California and Nevada]: Mines and mining in the States and Territories west of the Rocky Mountains, Sixth Ann. Rept. [for 1873], pp. 27–39, 196–197, 1874.

———8. The mining and metallurgy of quicksilver; Mines and mining in the States and Territories west of the Rocky Mountains, Sixth Ann. Rept. [for 1873], pp. 379–407, 1874.

———9. Condition of the mining industry [quicksilver in California, Nevada, and Oregon]: Mines and mining in the States and Territories west of the Rocky Mountains, Seventh Ann. Rept. [for 1874], pp. 13, 15, 173, 189, 271, 316, 317, 1875.

———10. Condition of the mining industry [quicksilver in California]: Mines and mining in the States and Territories west of the Rocky Mountains, Eighth Ann. Rept. [for 1875], pp. 3–15, 18–21, 1877.

Raymond, R. W., and Ingalls, W. R. 1. The mineral wealth of America [quicksilver]: Am. Inst. Min. Eng. Bull. 27, pp. 251, 255, March, 1909.

Revista Semanal. 1. Azogue [quicksilver in California and Mexico]: No. 6, New York, July 28, 1917.

Richardson, C. H. 1. Economic geology [mercury; its properties, occurrence, and uses], pp. 126–130, New York, McGraw-Hill Book Co., 1913.

Rickard, T. A., and Ralston, O. C. 1. Flotation [cinnabar subject to flotation], p. 71, San Francisco, Min. and Sci. Press, 1917.

Ries, Heinrich. 1. Economic geology [mercury], 4th ed., pp. 771–778, 1916.

Robertson, M. 1. Light that kills bacteria [mercury vapor lamp]: Illus. World, vol. 26, pp. 118–119, diags., September, 1916.

Rogers, A. F. 1. Eglestonite from San Mateo County, Cal.: Am. Jour. Sci., 4th ser., vol. 32, pp. 48–50, 1911.

———2. Some notes on the rare minerals of California [metacinnabarite from San Benito County]: Min. and Eng. World, vol. 37, p. 105, July 20, 1912.

Rolland, G. 1. Les gisements de mercure de Californie: Annales des mines, 7th ser., vol. 14, pp. 384–432, 1878.

Rundall, W. H. 1. Mining and treatment of quicksilver ores at Guadalcazar, Mexico: Eng. and Min. Jour., vol. 59, pp. 607–609, illus., June 29, 1895; Sci. Am. Suppl., vol. 40, pp. 16289–16290, July 13, 1895.

Sachs, A. 1. Zinnoberkristalle aus Sonoma County in Kalifornien; Gips und Kalkspatkristalle von Terlingua in Texas: Centralbl. Mineralogie, No. 1, 1907, pp. 17–19, 1907.

Salt Lake Mining Review. 1. Saving gold and cinnabar: Vol. 14, p. 23, May 15, 1912.

———2. Great cinnabar discovery [near Mina, Nev.]: Vol. 15, pp. 17–18, July 15, 1913.

———3. Quicksilver for explosives: Vol. 16, p. 24, Oct. 30, 1914.

———4. Quicksilver in California: Vol. 18, p. 39, Apr. 15, 1916.

Sandberger, F. 1. Ueber merkwürdige Quecksilbererze aus Mexico: K.-bayer. Akad. Wiss. München Sitzungsber., Bd. 5, H. 2, pp. 202–205, July 3, 1875.

Sanford, Samuel, and Stone, R. W. 1. Useful minerals of the United States [cinnabar or quicksilver in California, Colorado, Nevada, Oregon, Texas, and Utah]: U. S. Geol. Survey Bull. 585, pp. 35, 48, 117, 155, 182, 185, and 187, 1914.

San Francisco Commercial Herald. 1. Quicksilver production and trade of California: In Raymond, Mines and mining in the States and Territories west of the Rocky Mountains, Eighth Ann. Rept. [for 1875], pp. 461–462, 1877.

Santa Clara Mining Association of Baltimore. 1. First Ann. Rept., 13 pp., Baltimore, 1857. Pamphlet.

———2. Eighth annual report. 8 pp., Apr. 6, 1863. Pamphlet.

Schaller, W. T. 1. The properties of mosesite [mercury mineral from Terlingua, Tex.]: U. S. Geol. Survey Bull. 509 (Mineralogical notes, ser. 2), pp. 104–109, 1912.

Schrader, F. C., Stone, R. W., and Sanford, Samuel. 1. Useful minerals of the United States (a revision of U. S. Geol. Survey Bull. 585): U. S. Geol. Survey Bull. 624, 412 pp., 1917.

Schrauf, A. 1. Aphorismen über Zinnober: Zeitschr. prakt. Geologie, Bd. 2, pp. 10–18, January, 1894.

Scientific American. 1. A mercury-vapor engine: Vol. 112, p. 494, 1915.

———2. The freezing point of mercury: Vol. 115, pp. 473, 527, Dec. 9, 1916.

Scientific American Supplement. 1. The critical temperature of mercury: Vol. 80, p. 393, Dec. 18, 1915.

———2. The damping of waves and other disturbances in mercury: Vol. 83, No. 2140, p. 5, Jan. 6, 1917.

———3. The freezing point of mercury: Vol. 83, No. 2154, pp. 232 and 405, Apr. 14, 1917.

Scott, Robert. 1. Modern quicksilver reduction: Min. and Sci. Press, vol. 100, p. 164, Jan. 22, 1910.

Seamon, W. H. 1. A volumetric method for the determination of mercury: Eng. and Min. Jour., vol. 87, pp. 1047–1048, May 22, 1909.

Sharwood, W. J. 1. The determination of mercury in cyanide solution and precipitate: Min. and Sci. Press, vol. 111, pp. 663–665, Oct. 30, 1915.

———2. The estimation of gold and silver in mercury and amalgam, and the preparation of pure mercury: Am. Inst. Min. Eng. Trans., vol. 52, pp. 158–161, 1916.

Shaw, C. P. 1. Argument before the U. S. Senate Committee, Forty-second Congress, in support of the claim of William McGarrahan for the Rancho Panoche Grande, Cal., 320 pp., Washington, 1872.

Shockley, W. S. 1. Quicksilver in Nevada: Mineral Industry, vol. 17, p. 745, 1909.

Silliman, B., jr. 1. Notes on the New Almaden quicksilver mines: Am. Jour. Sci., 2d ser., vol. 38, pp. 190–194, 1864.

Simonds, F. W. 1. The minerals and mineral localities of Texas [cinnabar and mercury]: Texas Univ. Min. Survey Bull 5, pp. 20, 55, Dec., 1902.

Skidmore, W. A. 1. Quicksilver mining; progress in Napa, Lake, and Sonoma counties, Cal.: Min. and Sci. Press, vol. 27, p. 152, Sept. 6, 1873.

——— 2. Quicksilver in California: In Raymond, Mines and mining in the States and Territories west of the Rocky Mountains, Seventh Ann. Rept. [for 1874], pp. 13, 15, 173, 189, 1875.

Smith, G. O. 1. Quicksilver [cinnabar]: U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (No. 106), p. 9, 1904.

——— 2. Mid-year review of mining industry, 1915; special demand for quicksilver: Min. and Eng. World, vol. 43, p. 59, July 10, 1915.

Smith, J. A. 1. Catalogue of the minerals of Colorado [mercury]: Colorado State Geologist Bienn. Rept., 1880, p. 64, 1881.

Smith, P. S. 1. The Lake Clark-Central Kuskokwin region, Alaska [quicksilver]: U. S. Geol. Survey Bull. 655, pp. 131, 139–150, 1917.

Smith, P. S., and Maddren, A. G. 1. Quicksilver deposits of the Kuskokwin region [Alaska]: U. S. Geol. Survey Bull. 622, pp. 272–291, 1915.

Smith, R. O. 1. The rapid precipitation of lead and mercury in the electrolytic way, 20 pp., Easton, Pa., 1905.

Smith, S. W. J., and Moss, H. 1. Experiments with mercury jets: Roy. Soc. London, Proc., ser. A, vol. 93, pp. 373–393, figs., July 2, 1917.

Spaluing, E. P. 1. The quicksilver mines of Brewster County, Tex.: Eng. and Min. Jour., vol. 71, pp. 749–750, June 15, 1901.

Spencer, L. J. 1. The world's minerals [cinnabar], pp. 68–69, pl. 6, figs. 2, 3, 1911; 2d ed., with an appendix by W. D. Hamman, pp. 88–89, pl. 6, figs. 2, 3; pp. 279–282, 1916.

Spirek, Vincente. 1. The metallurgy of quicksilver: Mineral Industry, vol. 8, pp. 493–494, 1900.

Spurr, J. E., and Post, W. S. 1. Report of the Kuskokwim expedition [occurrence of cinnabar]: U. S. Geol. Survey Special Publication, maps and descriptions of routes of exploration in Alaska in 1898, p. 37, 1899.

Stafford, O. F. 1. The mineral resources and mineral industry of Oregon for 1903 [mercury]: Oregon Univ. Bull., new ser., vol. 1, pp. 98–100, 1904.

Stillman, M. H. The damping of waves and other disturbances in mercury: Bur. Standards Bull., vol. 13, pp. 563–568, Mar. 6, 1917. Abstract, Sci. Am., vol. 115, p. 527, Dec. 9, 1916.

Storms, W. H. Quicksilver production of California: Min. and Sci. Press, vol. 104, p. 400, Mar. 16, 1912.

Stovall, D. H. 1. Quicksilver mining in Oregon: Min. World, vol. 22, p. 137, Jan. 28, 1905.

——— 2. Oregon's quicksilver mine: Los Angeles Min. Rev., vol. 17, No. 9, p. 11, Mar. 4, 1905.

——— 3. Quicksilver extraction: Los Angeles Min. Rev., vol. 18, No. 7, p. 7, Aug. 12, 1905.

——— 4. The cinnabar deposits of Oregon: Min. World, vol. 25, p. 205, Aug. 25, 1906.

Strauss, L. W. 1. Modern quicksilver reduction: Min. and Sci. Press, vol. 100, p. 431, Mar. 19, 1910.

Struthers, Joseph. 1. Quicksilver: U. S. Geol. Survey Mineral Resources, 1901, pp. 235–238, 1902.

——— 2. Quicksilver: Mineral Industry, vol. 11, pp. 540–543, 547, 1903.

——— 3. Quicksilver: U. S. Geol. Survey Mineral Resources, 1902, pp. 251–258, 1904.

——— 4. Quicksilver industry in the United States and foreign countries: Min. World, vol. 21, pp. 79–80, July 23, 1904.

——— 5. Quicksilver: U. S. Bur. Census, Spec. Repts., Mines and quarries, 1902, pp. 649–657, 1905.

Symington, R. B. 1. Present practice in the metallurgy of quicksilver in California: Mineral Industry, vol. 7, pp. 582–588, 1899.

Szilard, Béla. 1. Process of separating mercury from poor ores by electrolysis: U. S. Patent No. 980364, Jan. 3, 1911.

Tate, J. T. 1. The passage of low-speed electrons through mercury vapor and the ionizing potential of mercury vapor: Physical Review, 2d ser., vol. 10, pp. 81–83, 1917.

Texas Mineral Resources. 1. Quicksilver deposits of Brewster County, Tex.: Vol. 1, No. 3, p. 7, Jan., 1917.

Thom, W. T. 1. Quicksilver in 1906; U. S. Geol. Survey Mineral Resources, 1906, p. 15, 1907.

——— 2. Quicksilver in 1907: U. S. Geol. Survey Mineral Resources, 1907, pt. 1, p. 9, 1908.

Thom, W. T. 3. Quicksilver in 1908: U. S. Geol. Survey Mineral Resources, 1908, pt. 1, pp. 9–10, 1909.

———4. Quicksilver in 1909: U. S. Geol. Survey Mineral Resources, 1909, pt. 1, p. 10, 1911.

———5. Quicksilver in 1910: U. S. Geol. Survey Mineral Resources, 1910, pt. 1. p. 12, 1911.

———6. Quicksilver in 1913: U. S. Geol. Survey Mineral Resources, 1913, pt. 1, pp. cxxx-cxxxi, cxlvii, 1914.

Thomas, Kirby. 1. Quicksilver in Mexico: Mineral Industry, vol. 18, pp. 621–622, 1910.

Thornhill, E. B. 1. Wet method of mercury extraction: Min. and Sci. Press, vol. 110, pp. 873–874, June 5, 1915.

———2. Recovery of mercury from residues of amalgamated cobalt ores: Canadian Min. Inst. Month. Bull. 36, pp. 263–268, April, 1915.

———3. Recovery of mercury from amalgamation tailing: Min. and Sci. Press, vol. 111, pp. 211–212, Aug. 7, 1915.

———4. Recovery of mercury from amalgamation tailing, Buffalo mines, Cobalt [Ontario]: Am. Inst. Min. Eng. Trans., vol. 52, pp. 165–169; discussion, pp. 169–170, 1916.

Todd, Aurelius. 1. The quicksilver mines of Oregon: West Am. Scientist, vol. 4, pp. 65–66, June, 1895.

Topographic map of the Terlingua quicksilver district, Brewster County, Tex. 1. In Texas Univ. Min. Survey Bull. 4, October, 1902.

Topographic map of Terlingua quadrangle, Brewster and Presidio counties, Tex. 1. In Texas Univ. Min. Survey Bull. 7, 1904.

Turner, H. W. 1. Further contributions to the geology of the Sierra Nevada [occurrence of cinnabar]: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, pp. 677–678, 1896.

———2. The Terlingua quicksilver mining district, Brewster County, Tex.: Min. and Sci. Press, vol. 81, p. 64, July 21, 1900.

———3. The Terlingua quicksilver deposits: Econ. Geology, vol. 1, pp. 265–281, 3 figs., December–January, 1905–1906.

———4. Modern quicksilver reduction: Min. and Sci. Press, vol. 99, p. 690, Nov. 20, 1909.

———5. Quicksilver in 1908: Eng. and Min. Jour., vol. 87, p. 141, Jan. 9, 1909.

———6. Quicksilver: Mineral Industry, vol. 17, pp. 742–745, 749–750, 1909.

———7. Quicksilver: Mineral Industry, vol. 18, pp. 617–619, 621, 1910.

———8. Modern quicksilver reduction: Min. and Sci. Press, vol. 100, p. 431, Mar. 19, 1910.

———9. Quicksilver in the United States in 1909: Eng. and Min. Jour., vol. 89, p. 82, Jan. 8, 1910.

Turner, H. W., and Ransome, F. L. 1. Quicksilver deposits [cinnabar]: U. S. Geol. Survey Geol. Atlas, Sonora folio (No. 41), p. 7, 1897.

Tyson, P. T. 1. Geology and industrial resources of California [cinnabar and quicksilver]: 31st Cong., 1st sess., Senate Ex. doc. 47, pp. 24, 36–37, 1850.

Udden, J. A. 1. A sketch of the geology of the Chisos country, Brewster County, Tex.: Texas Univ. Bull. 93 (Sci. ser. 11), 101 pp., April 15, 1907.

———2. Structural relations of quicksilver deposits [Texas]: Min. World, vol. 34, pp. 973–975, 6 figs., May 13, 1911.

———3. The geology of Texas quicksilver deposits: Texas Mineral Resources, vol. 1, pp. 1–2, 28–29, 4 figs., map, April, 1917.

———4. Deposits of quicksilver in Texas: Min. American, vol. 75, 1858, pp. 3–5, Sept. 29, 1917.

Udden, J. A., and Baker, C. L. 1. Economic mineral products [of Texas] [quicksilver]: Texas Univ. Bull. 44, pp. 117–118, Aug. 5, 1916.

Van Wagenen, T. F. 1. American metal mining; quicksilver: Min. Reporter, vol. 42, pp. 293–294, 311, 331, 1900.

Veatch, J. A. 1. The mercury deposits of the Pacific coast: Min. and Eng. World, vol. 40, pp. 591–594, sketch map, Mar. 28, 1914.

———2. The genesis of the mercury deposits of the Pacific coast: Am. Inst. Min. Eng. Bull. 86, pp. 209–226, 3 figs. (maps), February, 1914.

Villarello, J. D. 1. Genesis de los yacimientos mercuriales de Palomas (Durango) et Huitzuco (Guerrero): Soc. cient. Ant. Alzate Mem. y Rev., t. 19, pp. 95–136, 1903.

———2. Descripción de los criaderos de mercurio de Chiquilistlán (Jalisco): Soc. cient. Ant. Alzate Mem. y Rev., t. 20, pp. 389–397, 1904.

Villarello, J. D. 3. Description des mines "La Bella Union" [État de Guerrero]. Génèse des gisements de mercure: Soc. cient. Ant. Alzate Mem. y Rev., t. 23, pp. 395–411, 1906.

Virlet d'Aoust, Pierre Théodore. 1. De l'âge géologique de quelques filons métalliques et en particulier des filons de mercure (extrait): Compt. Rend., vol. 83, pp. 289–291, 1876.

Vivian, William. 1. Observations on the mining district of Sonora, Tuolumne County, Cal.: Cornwall Roy. Geol. Soc. Trans., vol. 7, pp. 216–219, 1865.

Wagoner, Luther. 1. Report on Guadalupe quicksilver mine, Cal: Eng. and Min. Jour., vol. 34, pp. 185–186, Oct. 7, 1882.

———2. The geology of the quicksilver mines of California: Eng. and Min. Jour., vol. 34, p. 334, 1 fig., Dec. 23, 1882.

Walcott, C. D. 1. Statistics of quicksilver: U. S. Geol. Survey Sixteenth Ann. Rept., pt. 1, pp. 51, 59, 1896.

———2. Statistics of quicksilver in 1895: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, pp. 84, 92, 1896.

———3. Statistics of production of quicksilver: U. S. Geol. Survey Eighteenth Ann. Rept.., pt. 1, pp. 84–85, 1897.

———4. Statistics concerning quicksilver: U. S. Geol. Survey Nineteenth Ann. Rept., pt. 1, p. 77, 1898.

———5. Statistics of production of quicksilver: U. S. Geol. Survey Twentieth Ann. Rept., pt. 1, p. 80, 1899.

———6. Publications on deposits of quicksilver; statistics of production: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 1, pp. 29, 104, 1900.

———7. Production of quicksilver in 1900: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 1, p. 112, 1901.

———8. Statistics of quicksilver: U. S. Geol. Survey Twenty-third Ann. Rept., p. 87, 1902.

———9. Statistics of quicksilver: U. S. Geol. Survey Twenty-fourth Ann. Rept., pp. 111–112, 1903.

———10. Statistics of quicksilver: U. S. Geol. Survey Twenty-fifth Ann. Rept., pp. 88–89, 1904.

———11. Statistics of quicksilver: U. S. Geol. Survey Twenty-sixth Ann. Rept., p. 84, 1905.

Watson, R. B. 1. [Discovery of mercury in silver ore]: Eng. and Min. Jour., vol. 94, pp. 1077–1080, Dec. 7, 1912.

Watts, W. L. 1. Alameda County, Cal. [quicksilver]: California State Min. Bur. Eleventh Rept., pp. 121–122, 1893.

———2. Colusa County, Cal.; the mines of Sulphur Creek and vicinity: California State Min. Bur. Eleventh Rept., pp. 181–187, 1893.

———3. Lake County [Cal.]; the Abbott quicksilver mines: California State Min. Bur. Eleventh Rept., pp. 239–240, 1893.

———4. Santa Clara County, Cal. [quicksilver]: California State Min. Bur. Eleventh Rept., p. 374, 1893.

———5. Sonoma County, Cal.; quicksilver at the Great Eastern mine and at Pine Flat district: California State Min. Bur. Eleventh Rept., pp. 460–461, 1893.

———6. Stanislaus County, Cal.; the Summit quicksilver mine: California State Min. Bur. Eleventh Rept., pp. 464–465, 1893.

Weaver, C. E. 1. Geology and ore deposits of the Blewett mining district (Chelan County, Wash.) [cinnabar] : Washington Geol. Survey Bull. 6, p. 78, 1911.

Weed, W. H. 1. Influence of country-rock on mineral veins: Am. Inst. Min. Eng. Trans., vol. 33, pp. 634–653, 1902.

———2. Ore deposition and vein enrichment by ascending hot waters: Am. Inst. Min. Eng. Trans., vol. 33, pp. 747–754, 1903.

Wells, W. V. 1. A visit to the quicksilver mines of New Almaden: Harper's New Monthly Mag., pp. 25–40, illus., June, 1863.

Wendeborn, B. A. 1. Die Quecksilberablagerungen in Oregon: Berg- u. hüttenm. Zeitung, vol. 63, pp. 274–277, 1904.

Whitehill, H. R. 1. Mineral resources of Nevada [cinnabar]: Nevada State Mineralogist Bien. Rept. for 1877 and 1878, p. 6, 1879.

Whitney, J. D. 1. The metallic wealth of the United States [mercury], pp. 186–187, 193–197, 1854.

———2. Notice of cinnabar from Nevada Territory: California Acad. Nat. Sci. Proc., vol. 2, p. 161, 1863.

Whitney, J. D. 3. Geology of the Coast Ranges [quicksilver and quicksilver rock]; California Geol. Survey Geology, vol. 1, pt. 1, pp. 16, 19, 68, 69, 71, 83, 89, 90, 1865.

———4. Geology of the Coast Ranges [occurrence of cinnabar]: California Geol. Survey, Geology, vol. 1, pt. 1, pp. 24, 58, 60, 72, 78, 91, 92, 114, 1865.

———5. The geology of the Sierra Nevada [occurrence of cinnabar]: California Geol. Survey, Geology, vol. 1, pt. 2, pp. 230–260, 1865.

Whitton, W. W. 1. The determination of mercury in ores: California Jour. Tech., vol. 4, pp. 35–36, Sept., 1904.

Wilhelm, R. M. 1. Freezing point of mercury: Bur. Standards Sci. Papers, No. 294, pp. 655–661, Oct. 26, 1916; Bull.. vol. 13, No. 4, pp. 655–661, Mar. 6, 1917. Abstract, Sci. Am., vol. 115, p. 527, Dec. 9, 1916.

Williams Albert, jr. 1. Quicksilver [California] and vermilion: U. S. Geol. Survey Mineral Resources, 1882, pp. 387, 398, 1883.

———2. Useful minerals of the United States; division of the Rocky Mountains [cinnabar in California, Colorado, Nevada, Utah]: U. S. Geol. Survey Mineral Resources, 1882, pp. 753, 767, 768, 772, 774, 1883.

———3. Statistics of quicksilver [United States]: U. S. Geol. Survey Fourth Ann. Rept., p. 65, 1884.

———4. Quicksilver [California] and vermilion: U. S. Geol. Survey Mineral Resources, 1883 and 1884, pp. 492–503, 1885.

———5. Quicksilver [California] and vermilion: U. S. Geol. Survey Mineral Resources, 1885, pp. 284, 296, 1886.

———6. Statistics of quicksilver [United States]: U. S. Geol. Survey Seventh Ann. Rept., p. 132, 1888.

———7. Useful minerals of the United States [cinnabar in California, Colorado, Idaho, Nevada, Oregon, and Utah]: U. S. Geol. Survey Mineral Resources, 1887, pp. 703, 705, 713, 724, 756, 778, and 796, 1888.

Willis, C. F. 1. Arizona—mercury: Arizona State Bur. Mines Bull. 6 (Econ. ser. 3), p. 15, 1915–16.

———2. Mineralogy of useful minerals in Arizona: Arizona Univ. Bur. Mines Bull. 41 (Econ. ser. 11), p. 30, 1916–17.

Winchell, A. N. 1. Petrology and mineral resources of Jackson and Josephine counties, Oreg. [mercury]: Oregon Bur. Mines and Geology Mineral Resources of Oregon, vol. 1, pp. 65, 124, 129, 161, Aug., 1914.

Wolf, A. G., Liberty Bell mercury trap; Min. and Sci. Press, vol. 115, p. 206, 1 fig., 1917.

Yale, C. G. 1. Quicksilver product of California for 1874: In Raymond, Mines and mining in the States and Territories west of the Rocky Mountains, Seventh Ann. Rept. [for 1874], p. 493, 1875.

———2. Minor minerals of the Pacific coast: U. S. Geol. Survey Mineral Resources, 1882, pp. 662–663, 1883.

———3. California [quicksilver]: Eng. and Min. Jour., vol. 79, p. 21, Jan. 5, 1905.

———4. The mining industries of California: Eng. and Min. Jour., vol. 81, pp. 19–20, Jan. 6, 1906.

———5. California quicksilver: Eng. and Min. Jour., vol. 81, pp. 46–47, Jan. 6, 1906.

———6. Quicksilver mining in California: Mineral Industry, vol. 14, pp. 503–506, 1906.

———7. Quicksilver in California: Min. and Sci. Press, vol. 94, p. 22, Jan. 5, 1907.

———8. Quicksilver in California: Mineral Industry, vol. 15, pp. 675–676, 1907.

———9. Quicksilver in California: Eng. and Min. Jour., vol. 85, p. 89, Jan. 4, 1908.

———10. Quicksilver in California: Mineral Industry, vol. 16, p. 814, 1908.

Young, G. A. 1. A descriptive sketch of the geology and economic minerals of Canada [mercury], p. 132, Ottawa, Government Printing Bureau, 1909. [At head of title: Canada Dept. Mines, Geol. Survey Branch. . .]

GOLD, SILVER, COPPER, LEAD, AND ZINC IN IDAHO.

(MINES REPORT.)

By C. N. Gerry.

PRODUCTION.

GENERAL STATEMENT.

The value of the mine production of gold, silver, copper, lead, and zinc in Idaho in 1917 was $54,845,153, an increase of 12 per cent over the value in 1916. There was a slight decrease in silver, larger decreases in copper and zinc, and a considerable decrease in gold. The output of lead, however, exceeded that of 1916 by nearly 5 per cent, making a record greater than that of any previous year. The total value was augmented by greatly increased prices of silver, copper, and lead. Thus the value of the output was also a record for the State notwithstanding several decreases in quantity of the metals. Dividends for 1917, partly estimated, amounted to $9,900,691.

The production of the State from the discovery of placer gold to the end of 1917 is given in the table below. The total to 1914, inclusive, has been previously given by periods.[1] The complete table shows that the State has been an important producer of the five metals, which have a total value of nearly $618,000,000. Of this total, lead represents $280,011,845, or more than 45 per cent; silver, $152,779,842, or nearly 25 per cent; gold, $130,910,969, or more than 21 per cent; copper, $19,561,431, or more than 3 per cent; and zinc, $34,299,118, or nearly 6 per cent. The value of the mine production in 1917 exceeded the combined total value of zinc and copper from 1863 to the end of 1917.

Mine production of gold, silver, copper; lead, and zinc in Idaho in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	418	2,718,045	$1,115,810	12,300,873	8,478,281	375,081,781	86,505,219	$48,767,783
1917	359	2,758,507	804,809	12,029,338	7,827,574	393,559,521	79,854,136	54,845,153
Increase or decrease, 1917		+40,462	−311,001	−271,535	−650,707	+18,477,740	−6,651,083	+6,077,370
Total, 1863–1917			130,910,969	224,705,955	116,364,929	5,771,348,252	341,218,640	617,563,205

---

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 598, 1915.

The table giving the separation according to source of metals shows a distinct increase in lead from lead ore, but a decrease in zinc from lead-zinc ore, and a decided decrease in the placer output of gold. There was a decrease in the price of zinc, especially during the last months of the year, and the market for a mixed ore was uncertain.

Ore and metals produced in Idaho in 1917.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	121	....	6,541.80	1,194	....	....	....
Dry or siliceous ore	86	69,650	24,929.28	81,514	10,745	48,689	....
Copper ore	37	103,224	3,960.99	232,840	6,225,486	11,803	....
Lead ore	107	1,448,285	2,567.41	8,063,768	1,250,215	275,019,571	....
Zinc ore	14	19,269	....	29,684	....	602,096	10,824,568
Copper-lead ore	1	4	....	803	320	848	....
Lead-zinc ore	19	1,118,075	933.16	3,619,535	340,808	117,876,514	69,029,568
	....	2,758,507	38,932.64	12,029,338	7,827,574	393,559,521	79,854,136

ORE.

The quantity of ore sold or treated in Idaho in 1917 increased 40,462 tons, or about 1.5 per cent. Most of the output was lead ore and lead-zinc ore, the former being nearly 53 per cent of the total and the latter 40 per cent. Copper ore represented nearly 4 per cent of the total; siliceous ore, nearly 3 per cent; and zinc ore and copper-lead ore, less than 1 per cent. Much of the lead ore contains zinc that is not saved at a lead smelter, but most of the concentration mills make a separate zinc product, which is shipped to a zinc smelter or an electrolytic plant. The total ore mined and treated had an average value per ton in gold and silver of $19.83. The average values in gold and silver for each kind of ore are shown at the foot of the following table. The siliceous ore sold or treated averaged per ton as follows: Gold, $7.40; silver, 1.17 ounces; with a trace of copper and lead. The siliceous ore included 67,784 tons of gold ore, averaging per ton $7.54 in gold and 0.39 ounce of silver; and 1,866 tons of silver ore, averaging per ton $2.27 in gold, 29.66 ounces of silver, 0.52 pound of copper, and 2.39 pounds of lead. The copper ore averaged per ton 79 cents in gold and 2.26 ounces of silver, and contained 3.02 per cent of copper. Most of the siliceous ore was treated by amalgamation or cyanidation, and most of the copper ore was shipped directly to smelters. The averages of the crude shipping product are given later. Lead ore as mined averaged 3.6 cents in gold and 5.57 ounces of silver per ton, and contained 0.043 per cent of copper and 9.49 per cent of lead. The total zinc ore mined or treated averaged per ton 1.54 ounces of silver, and contained 1.56 per cent of lead and 28.09 per cent of recoverable zinc. Copper-lead ore, only 4 tons, averaged per ton 200.75 ounces of silver, and contained 4 per cent of copper and 10.60 per cent of lead. Lead-zinc ore averaged per ton 1.7 cents in gold and 3.24 ounces of silver, and contained 0.015 per cent of copper, 5.27 per cent of lead, and 3.09 per cent of recoverable zinc. Most of the lead ore and lead-zinc ore was milled, and the results are given within after the table on concentrates.

Ore sold or treated in Idaho in 1917, in short tons.

County.	Dry or silicious ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Ada	20						20
Adams		165					165
Blaine	20		9,992	262		10,456	20,730
Boise	27,571		19				27,590
Bonner	19		762				781
Bonneville		2					2
Boundary	20	4	38,567				38,591
Butte	1	153	5,744				5,898
Camas	985		14				999
Cassia	127			20			147
Custer	1,201	68,832	13,670				83,703
Elmore	25,616						25,616
Fremont		509	216				725
Gem	4						4
Idaho	11,332	19					11,351
Latah		59					59
Lemhi	1,653	867	16,528				19,048
Owyhee	871						871
Shoshone	158	32,614	1,362,745	18,987	4	1,107,619	2,522,127
Valley	52						52
Washington			28				28
	[a] 69,650	103,224	1,448,285	19,269	4	1,118,075	2,758,507
Average value per ton in gold and silver	$8.36	$2.65	$4.62	$1.27	$165.41	$2.68	$3.84

[a] Includes 67,784 tons of gold ore and 1,866 tons of silver ore.

More than 2 per cent of the ore (67,677 tons) was treated in gold and silver mills in 1917, against 69,773 tons in 1916. Bullion from this ore treated by amalgamation and cyanidation was valued at $486,889, or $7.19 per ton. Idaho County led in production of bullion, and Boise County was second. There was a decided decrease in Elmore County, which was first in 1916. Nearly all the gold in bullion was won by amalgamation, only about 5 per cent being recovered by cyanidation. At these mills during 1917 there were 1,035 pounds of mercury and 4,996 pounds of potassium and sodium cyanide consumed. The average consumption of quicksilver was 0.0162 pound per ton of ore amalgamated and 0.032 pound per ounce of gold and silver bullion saved. The cyanide consumption was 1.30 pounds per ton of ore treated and 0.45 pound per ounce of gold and silver bullion recovered.

Gold and silver produced in mills in Idaho in 1917.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Ada	20	15.34	14			$328
Blaine	2			1.24	11	35
Boise	26,251	7,770.52	1,393	704.15	604	176,832
Butte	1	1.58	2			35
Camas	[a] 985	310.02	122			6,509
Custer	[b] 1,201	160.65	502			3,734
Elmore	[c] 25,592	3,376.38	2,330	412.26	5,409	84,695
Gem	4			.85	53	61
Idaho	[d] 11,154	9,594.02	4,687	9.51	1	202,386
Lemhi	1,617	169.98	47			3,553
Owyhee	[e] 801	134.43	1,970	23.87	3,697	7,942
Shoshone	1	.77				16
Valley	48	35.53	35			763
	67,677	21,569.22	11,102	1,151.88	9,775	486,889

[a] Also yielded 19 tons of concentrates.

[b] Also yielded 62 tons of concentrates.

[c] Also yielded 130 tons of concentrates.

[d] Also yielded 3 tons of concentrates.

[e] Also yielded 68 tons of concentrates.

More than 86 per cent of the ore, or 2,375,891 tons, was concentrated. Concentrates from this ore, from 28,215 tons of old tailings treated, and from a small quantity of ore treated in gold and silver mills aggregated 419,182 tons, valued at $38,405,236, or $91.62 a ton in 1917, against $90.55 a ton in 1916. The concentrates were largely from the Coeur d'Alene region, and the ratio was 5.7 tons of ore to 1 ton of concentrate. Nearly 77 per cent of the total was lead concentrate, more than 19 per cent lead-zinc concentrate, and less than 4 per cent was zinc concentrate, copper concentrate, and siliceous concentrate. There was good increase in lead concentrate and zinc concentrate, but the lead-zinc concentrate was less. As each year shows a variation from one class to another, the important feature is the fact that the mills made 32,823 tons more concentrate in 1917. Operators in Shoshone County shipped an average of 33,967 tons of concentrates of various kinds per month, against 31,664 tons in 1916. The crude ore shipped, which was 14,943 tons per month, being added gives the Coeur d'Alene region average monthly shipments of 48.910 tons of concentrates and crude ore, against 43,939 tons in 1916.

Mine production of metals from Idaho concentrates in 1917.

By counties.

County.	Ore to concentrating mills.	Concentrates produced.						Total value of concentrates.
		Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Blaine	14,874	5,315	472.68	118,684	4,586	1,263,791	1,949,866	$416,890
Boise	1,279	220	176.62	15,836	4,047	34,483		20,771
Bonner	762	127	.08	2,254	159	197,271		18,867
Boundary	37,856	4,732	24.11	109,184		5,850,609		593,619
Butte	2,923	835		12,525	3,120	885,100		87,292
Camas		19	74.07	134				1,641
Custer		62	392.95	2,855				10,475
Elmore		130	711.50	3,545				17,629
Idaho		3	20.14	140				531
Lemhi	248	62	111.29	363	30,072			10,810
Owyhee		68	341.60	8,185		8,407		14,529
Shoshone	2,317,949	407,609	1,684.72	7,770,764	1,290,226	278,132,199	63,756,334	37,212,682
	2,375,891	419,182	4,009.76	8,044,469	1,332,210	286,371,860	65,706,200	38,405,236

By kinds of concentrates.

	Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value of concentrates.
Dry or siliceous	245	1,303.51	27,829	163			$49,921
Copper	1.361	108.34	29,416	468,347			154,338
Lead	322,340	2,387.91	7,624,987	863,700	275,749,061		30,282.560
Zinc	15,245		46,805		830,640	10,066,224	1,136,758
Lead-zinc	79,991	210.00	315,432		9,792,159	55,639,976	6,781,659

The concentrates had the following average contents: Siliceous concentrates contained $109.98 in gold and 113.59 ounces of silver, or $203.76 per ton. Copper concentrates contained $1.65 in gold and 21.61 ounces of silver per ton, and also 17.21 per cent copper, a total value per ton of $113.40. Lead concentrates averaged 15 cents in gold and 23.66 ounces of silver per ton, and 0.13 per cent of copper and 42.77 per cent of lead, or a total value per ton of $93.94. Zinc concentrates averaged 3.07 ounces of silver per ton, 2.72 per cent of lead and 33.02 per cent of recoverable zinc, or a total value per ton of $74.57. Lead-zinc concentrates averaged per ton slightly more than 5 cents in gold and 3.94 ounces of silver and 6.12 per cent of lead and 34.78 per cent of recoverable zinc, or a total value per ton of $84.78. Averages for concentrates, as well as for shipping ore, from 1911 to 1914 were given in a previous report.[1]

Of the total ore, 284,567 tons, or more than 10 per cent, was shipped crude to smelters. There was a good increase in crude shipping ore from Shoshone County, which ranked first, as in former years. Custer County also increased its shipping product, supplying nearly 29 per cent of the total. In 1916 all of this ore went to plants outside of the State, but in 1917 part of the lead products were smelted at the Bunker Hill smelter, at Kellogg. The total value of the first-class ore was $15,753,519, or $55.36 a ton. There was a decided increase in lead ore and lead-zinc ore shipped, and a slight increase in copper ore. There was no great change in shipments of crude zinc ore. More than 64 per cent of the crude ore shipped was lead ore, nearly 28 per cent was copper ore, more than 4 per cent was zinc ore, and more than 3 per cent lead-zinc ore. The combined value of the concentrates and the crude ore shipped, most of which went to distant smelters, was $54,158,755. The ore smelted was principally sulphide in character. A close separation of oxidized and sulphide portions, with average content per ton, is as follows: Copper ore shipped consisted of 43,346 tons of oxidized and carbonate ore, averaging per ton $1.18 in gold and 1.02 ounces of silver, and 3.97 per cent of copper, or a total value per ton of $23.70, and of 35,183 tons of sulphide ore, averaging per ton 81 cents in gold and 3.77 ounces of silver, and 3.21 per cent of copper, or a total value per ton of $21.44. There was a greater difference in the lead ore, for the oxidized portion (29,012 tons) averaged per ton 42 cents in gold and 8.60 ounces of silver, and 0.23 per cent of copper and 17.35 per cent of lead, or a total value per ton of $38.60, and the sulphide lead ore shipped (154,079 tons) averaged per ton 10 cents in gold and 22.18 ounces of silver, and 0.19 per cent of copper and 30.92 per cent lead, or a total value per ton of $72.61. A small quantity (195 tons) of oxidized zinc ore averaged 31.68 per cent of recoverable zinc, and 12,459 tons of sulphide ore contained per ton 0.92 ounce of silver, and 2.36 per cent lead and 40.20 per cent of recoverable zinc. The lead-zinc ore and copper-lead ore shipped were sulphide.

---

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 601, 1915.

Mine production of metals from Idaho crude ore shipped to smelters in 1917.

By counties.

County.	Quantity.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Adams	165		152	31,080			$8,610
Blaine	692	13.84	26,915	2,230	302,262	168,509	66,256
Boise	60	14.90	6,493	276	9,338		6,536
Bonner	19	.84	3,085	748			2,764
Bonneville	2	.96	11	595			192
Boundary	735	7.38	12,398	704	663,525		67,624
Butte	2,974	82.40	24,526	28,450	1,674,808		173,712
Camas	14	11.47	469		4,490		1,010
Cassia	147	30.82	1,998		4,161	11,540	3,818
Custer	82,146	2,587.11	202,669	4,404,625	3,061,332		1,686,217
Elmore	24	208.44	445	241	1,333		4,857
Fremont	725	.48	1,008	162,367	122,927		55,739
Idaho	197	75.27	93	7,132			3,580
Latah	59	1.79	51	18,506			5,131
Lemhi	17,183	599.80	159,423	181,570	7,282,166		819,596
Owyhee	70	116.29	15,236				14,959
Shoshone	179,323	1,883.28	3,470,232	1,586,685	93,875,454	13,967,887	12,829,580
Valley	4	.85	720				611
Washington	28		168		30,106		2,727
	284,567	5,635.92	3,926,092	6,425,209	107,031,902	14,147,936	15,753,519

By kinds of ore.

Dry or siliceous	658	448.79	29,911	6,698	5,799		$36,252
Copper	78,529	3,846.61	177,164	5,699,584	124		1,781,496
Lead	183,091	1,326.52	3,667,378	718,607	105,363,081		12,306,746
Zinc	12,654		11,481		587,456	10,141,012	1,094,364
Copper-lead	4		803	320	848		822
Lead-zinc	9,631	14.00	39,355		1,074,594	4,006,924	533,839

The crude ore shipped had the following averages: Siliceous ore averaged per ton $14.10 in gold and 45.46 ounces of silver, and 0.51 per cent of copper and 0.44 per cent lead, or a total value per ton of $55.09; copper ore averaged $1.01 in gold and 2.26 ounces of silver per ton, and 3.63 per cent of copper, or a total value per ton of $22.69; lead ore averaged 15 cents in gold and 20.03 ounces of silver per ton, and 0.20 per cent of copper and 28.77 per cent lead, or a value per ton of $67.22; zinc ore averaged 0.91 ounce of silver, 2.32 per cent lead, and 40.70 per cent of recoverable zinc, or a total value per ton of $86.48; lead-zinc ore averaged per ton 3 cents in gold and 4.09 ounces of silver, and 5.58 per cent lead and 20.80 per cent of recoverable zinc, or a total value per ton of $55.43. Copper-lead ore smelted was small in quantity; the average contents have already been given.

GOLD.

The mine production of gold in Idaho in 1917 was 38,932.64 fine ounces, valued at $804,809, a decrease of $311,001, or nearly 28 per cent. Boise County was the largest producer of gold, but there was such a large decrease in 1917 that the output of Idaho County was nearly as large. Elmore, Shoshone, Custer, and Lemhi counties had large outputs. The gold output of Elmore and Lemhi counties decreased notably, but that of Idaho and Shoshone counties increased. The lode mines, 247 in number, produced gold valued at $669,578; and 112 placers produced gold valued at $135,231, against 162 placers and $449,093 in 1916. Of the placer gold, $59,447 was won by dredges, $52 by drift mines, and $75,732 by hydraulic or sluicing mines. The dredge output in 1917 decreased $268,249 from that of 1916, and gold recovered by sluicing and hydraulicking decreased $45,480. Of the total gold, nearly 17 per cent came from placers, more than 64 per cent from siliceous ore, nearly 7 per cent from lead ore, more than 10 per cent from copper ore, and more than 2 per cent from lead-zinc ore. Siliceous ores contained $7.40 a ton in gold; copper ore, 79 cents; lead ore, 3.6 cents; and lead-zinc ore, 1.7 cents. Snake River in various counties produced only $917 in gold, against $5,824 in 1916. The production of gold from amalgamation and cyanidation mills was slightly more. In 1917 bullion recovered in these mills contained 22,721.08 ounces of gold, or more than 58 per cent of the total, against 22,479.71 ounces in 1916. Amalgamation won 21,569.20 ounces of gold and cyanidation 1,151.88 ounces. Concentrates of all kinds contained only 4,009.76 ounces of gold, or more than 10 per cent of the total gold, and crude ore shipped to smelters contained 5,635.92 ounces of gold, or nearly 15 per cent of the total. Various sulphide shipping ores contained 2,125.87 ounces of gold and oxidized ores contained 3,510.05 ounces. A statement of dredges operated since 1897 and their output by years was given in a former report.[a] A total of $3,781,503 has been recovered by dredges.

In 1917 there were only four mines which had a gold output of more than $50,000 each. In order of their importance these were the Holte mine, in Idaho County; the Gold Hill & Iowa, in Boise County; Boise Rochester, in Elmore County; and Empire Copper Co., in Custer County.

Mine production of gold in Idaho in 1917, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Lead-zinc ore.	Total.
Ada	266.64	15.34				281.98
Benewah	153.93					153.93
Bingham	12.58					12.58
Blaine		5.35		197.41	303.00	505.76
Boise	1,854.70	8,652.23		13.96		10,520.89
Bonner		.84		.08		.92
Bonneville	104.64		.96			105.60
Boundary		4.23		27.26		31.49
Butte		1.58	2.49	79.91		83.98
Camas		384.09		11.47		395.56
Cassia		30.82				30.82
Clearwater	839.26					839.26
Custer	84.66	553.59	2,554.87	38.33		3,231.45
Elmore	46.25	4,708.58				4,754.83
Fremont				.48		.48
Gem	.68	.82				1.50
Gooding	1.64					1.64
Idaho	552.88	9,698.94				10,251.82
Latah	13.11		1.79			14.90
Lemhi	2,002.56	212.50	141.03	527.54		2,883.63
Lincoln	4.69					4.69
Nez Perce	.68					.68
Owyhee	.39	616.20				616.59
Power	11.27					11.27
Shoshone	576.15	7.79	1,259.85	1,670.97	630.16	4,144.92
Twin Falls	12.14					12.14
Valley	2.95	36.38				39.33
	6,541.80	[b] 24,929.28	3,960.99	2,567.41	933.16	38,932.64

---

[a] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 604, 1915.

[b] Includes 24,721.64 ounces from gold ore and 207.64 ounces from silver ore.

SILVER.

The mine production of silver decreased from 12,300,873 ounces in 1916 to 12,029,338 ounces in 1917, but the value increased from $8,093,974 to $9,912,175—a decrease of more than 2 per cent in quantity, but an increase of 22 per cent in value. Fair increase was made in Blaine, Boundary, and Custer counties, but large decrease in Shoshone and Lemhi counties. A separation of the silver according to source shows that the largest part of the total silver yield, or 67 per cent, was from lead ore, 30 per cent from lead-zinc ore, nearly 2 per cent from copper ore, and less than 1 per cent from siliceous ore, zinc ore, and copper-lead ore. Shoshone County produced more than 93 per cent of the silver. Concentrates supplied more than 66 per cent of the silver, shipping ore contained nearly 33 per cent, and gold and silver bullion contained only 0.17 per cent. Crude shipping ore averaged 13.80 ounces a ton and concentrates 19.19 ounces a ton. The silver contents of the different kinds of shipping ore have already been given. The Banner mine in Boise County and the Trade Dollar mine in Owyhee County produced ore in which the silver was far more valuable than the gold. Formerly Owyhee County produced much of this class of ore.

Six mines in Idaho produced a total of more than 9,000,000 ounces of silver in 1917; they were the Hercules, Bunker Hill & Sullivan, Hecla, Morning, Caledonia, and Greenhill-Cleveland. Each of these produced more than 800,000 ounces of silver.

Mine production of silver in Idaho in 1917, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper-ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Ada	57	14						71
Adams			152					152
Benewah	23							23
Blaine		2,171		110,825			43,060	156,056
Boise	452	23,995		331				24,778
Bonner		3,085		2,254				5,339
Bonneville	3		11					14
Boundary		12	8	121,562				121,582
Butte		2	228	36,823				37,053
Camas		256		469				725
Cassia		1,998						1,998
Clearwater	187							187
Custer	33	3,357	125,610	103,319				232,319
Elmore	16	11,729						11,745
Fremont			219	789				1,008
Gem		53						53
Idaho	129	4,921						5,050
Latah	1		51					52
Lemhi	161	78	862	158,893				159,994
Owyhee		29,088						29,088
Shoshone	130		105,699	7,528,335	29,684	803	3,576,475	11,241,126
Twin Falls	1							1
Valley	1	755						756
Washington				168				168
	1,194	[a] 81,514	232,840	8,063,768	29,684	803	3,619,535	12,029,338

[a] Includes 26,171 ounces from gold ore and 55,343 ounces from silver ore

COPPER.

The mine production of copper decreased from 8,478,281 pounds, valued at $2,085,657, in 1916 to 7,827,574 pounds, valued at $2,136,928, in 1917, a decrease of nearly 8 per cent in quantity but a slight increase in value. More than half of the copper came from Custer County, and about 37 per cent from Shoshone County. The Empire property, near Mackay, is still the largest copper producer in the State. In the Coeur d'Alene region the Richmond mine added considerable copper to the State output. Nearly 80 per cent of the total output was from copper ore, nearly 16 per cent from lead ore, and more than 4 per cent from lead-zinc ore. Concentrates contained about 17 per cent of the copper, and crude shipping ore of all kinds 82 per cent. Crude copper ore of shipping grade averages 3.13 per cent of copper, and copper concentrates 17.21 per cent. Smelting sulphide ore contained 3.21 per cent of copper, and oxidized ore 3.97 per cent. The average price of copper increased from 24.6 cents a pound in 1916 to 27.3 cents in 1917.

Mine production of copper in Idaho in 1917, in pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Copper lead ore.	Lead-zinc ore.	Total.
Adams		31,080				31,080
Blaine			19,416			19,416
Boise	4,129		194			4,323
Bonner	748		159			907
Bonneville		595				595
Boundary	57	147	500			704
Butte		21.185	10,385			31,570
Custer		4,419,707	42,473			4,462,180
Elmore	241					241
Fremont		161,454	913			162,367
Idaho	5,570	1,562				7,132
Latah		18,506				18,506
Lemhi		122,571	89,071			211,642
Shoshone		1,448,679	1,087,104	320	340,808	2,876,911
	[a] 10,745	6,225,486	1,250,215	320	340,808	7,827,574

[a] Includes 9,752 pounds from gold ore and 993 pounds from silver ore.

LEAD.

The mine production of lead increased from 375,081,781 pounds, valued at $25,880,643, in 1916 to 393,559,521 pounds, valued at $33,846,119, in 1917. The increase in quantity was nearly 5 per cent and in value nearly 31 per cent. The total establishes a new record for the State, which has increased its output of lead about 70 per cent since 1904. Aside from Shoshone County, which supplied nearly 95 per cent of the total, good production was made by Lemhi, Boundary, Custer, Butte, and Blaine counties. Lead ore supplied nearly 70 per cent of the total and lead-zinc ore nearly 30 per cent. The recoverable lead in lead ores sold or treated averaged 9.49 per cent, and that in lead-zinc are 5.27 per cent. Crude lead ore of shipping grade averaged 28.77 per cent of recoverable lead, and lead concentrates 42.77 per cent. Concentrates of all kinds produced nearly 73 per cent of the total. Lead concentrates had an average value per ton of $93.94. Crude ore shipped was the source of more than 27 per cent of the lead, and the lead ore shipped to smelter had an average value per ton of $67.22. Nearly all the lead in crude ore shipped was from sulphide ores, only 10,073,879 pounds coming from oxidized ores. The average price of lead for 1917 increased 1.7 cents over the price in 1916.

Seven mines produced more than 82 per cent of the State output of lead in 1917. These were the Bunker Hill & Sullivan, Hercules, Morning, Hecla, Consolidated Interstate-Callahan, Tamarack & Custer, and Greenhill-Cleveland. Each one produced more than 10,000,000 pounds of lead, and the Last Chance, Caledonia, and Gold Hunter followed closely.

Mine production of lead in Idaho in 1917, in pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Blaine	71		1,050,562			659,500	1,710,133
Boise	34,717		9,104				43,821
Bonner			197,271				197,271
Boundary			6,514,134				6,514,134
Butte			2,559,908				2,559,908
Camas			4,490				4,490
Cassia	4,161						4,161
Custer		11,803	3,061,208				3,073.011
Elmore	1,333						1,333
Fremont			122,927				122,927
Lemhi			7,282,166				7,282,166
Owyhee	8,407						8,407
Shoshone			254,187,695	602,096	848	117,217,014	372,007,653
Washington			30,106				30,106
	[a] 48,689	11,803	275,019,571	602,096	848	117,876,514	393,559,521

[a] Includes 44,223 pounds from gold ore and 4,466 pounds from silver ore.

ZINC.

The mine production of recoverable zinc decreased from 86,505,219 pounds, valued at $11,591,699, in 1916 to 79,854,136 pounds, valued at $8,145,122, in 1917. This decrease of 6,651,083 pounds in quantity and of $3,446,577 in value came almost entirely from the Coeur d'Alene region. The Consolidated Interstate-Callahan property retained first place among the zinc producers of the State. The zinc output from Blaine County increased decidedly in spite of numerous difficulties. Zinc has become an important product of Idaho, as will be seen from the value, which compares favorably with that of silver in 1917. Lead-zinc ore supplied more than 86 per cent and zinc ore nearly 14 per cent of the zinc. Both the zinc concentrates and the crude zinc ore shipped are sulphide products, except the 195 tons from Blaine and Cassia counties. From concentrates, both zinc and lead-zinc, 65,706,200 pounds of recoverable zinc were won, or 82 per cent of the total; and from crude ore shipped, 14,147,936 pounds were won, or nearly 18 per cent of the total. Flotation has proved an aid in most of the concentration mills, and much of the material is shipped for treatment at electrolytic plants. The average price of metallic zinc was 10.2 cents a pound in 1917, 3.2 cents less than the price in 1916.

Nine mines produced more than 1,000,000 pounds of spelter each in 1917. Named in order of importance, these were the Consolidated Interstate-Callahan, Success, Morning, Rex, Highland Surprise, Douglas, North Star, Greenhill-Cleveland, and Constitution.

Mine production of recoverable zinc in Idaho in 1917, in pounds.

County.	Zinc ore.	Lead-zinc ore.	Total.
Blaine	168,509	1,949,866	2,118,375
Cassia	11,540		11,540
Shoshone	10,644,519	67,079,702	77,724,221
	10,824,568	69,029,568	79,854,136

The source of the ore and the actual assay in zinc, without deduction for losses in smelting, are shown below. There were 117,521 tons of zinc ore, zinc concentrates, lead-zinc ore, and lead-zinc concentrates shipped, of which the gross content was 93,964,203 pounds of zinc, or an average of 39.98 per cent. Most of the output came from the Beaver, Hunter, Lelande, Placer Center, Summit, and Yreka districts, in Shoshone County, and the Warm Springs district in Blaine County. In 1916 the shipments were 115,463 tons of zinc ore and concentrates containing 101,738,293 pounds of zinc, or an average of 44.06 per cent.

Zinc ore, lead-zinc ore, and concentrates produced from Idaho mines sold in 1917.

Classification.	County.	Quantity (short tons, dry weight).	Average assay of ore and concentrate (per cent of zinc).[a]
Sulphide zinc ore and concentrates	Blaine and Shoshone	27,704	42.64
Sulphide lead-zinc ore and concentrates	do	89,622	39.15
Carbonate zinc ore	Blaine and Cassia	195	39.88
		117,521	39.98

[a] Actual zinc content.

REDUCTION PLANTS.

In Idaho 69 milling plants of all kinds were in operation in 1917, against 79 active mills in 1916. Of these mills, 40 were concentration plants, 23 of which used flotation machines with other concentrating devices; 3 used flotation alone; 13 used amalgamation alone; 2 used cyanidation; 12 used amalgamation and concentration; and 2 used amalgamation, concentration, and cyanidation. Most of the ore and concentrate was shipped outside the State for smelting, but in July, 1917, the new lead smelter and refinery of the Bunker Hill Co. began to treat material from the Coeur d'Alene region.

MINING INDUSTRY.

Notwithstanding conditions which tended to retard the output of metals in the State, the year 1917 was a success from the standpoint of the value of the output. This total value increased to nearly $55,000,000, and the net profits from the Coeur d'Alene region alone were nearly $13,000,000. There was an increase of about $600,000 in 1917, compared with an increase of $2,360,000 in 1916. Much of the increase was due to the higher prices of silver, copper, and lead. Compared with other States, Idaho was free from labor disturbances, but the mining industry was affected by the higher cost of material and supplies, scarcity of miners, impending law suits, and uncertainty regarding taxation.

In July the Bunker Hill smelter had its initial run, using one furnace. By the end of the year three furnaces and the refinery were in operation. As the suit with the American Smelting & Refining Co. was settled early in 1918 and the Bunker Hill smelter is in full operation, the plant will no doubt treat in 1918 a large percentage of the ore mined in the district. The smelter at Northport, Wash., was active throughout 1917, and nearly all of the material treated was lead ore and concentrates from Idaho. In the Pine Creek section hauling by wagon was still necessary as the branch railroad was not completed. The dredge of the Yukon Gold Co., at Murray, began operations in December, and it is hoped that the output in 1918 will compensate for the idleness of the Boston-Idaho dredge at Idaho City during 1917.

Mine production of gold, silver, copper, lead, and zinc in Idaho in 1917.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.		
	Quantity.	Value.	Quantity.	Value.		Quantity.	Value.
	Fine ounces.		*Fine ounces.*			*Fine ounces.*	
Ada	266.64	$5,512	15.34	$317	$5,829	71	$58
Adams						152	125
Benewah	153.93	3,182			3,182	23	19
Bingham	12.58	260			260		
Blaine			505.76	10,455	10,455	156,056	128,590
Boise	1,854.70	38,340	8,666.19	179,146	217,486	24,778	20,417
Bonner			.92	19	19	5,339	4,399
Bonneville	104.64	2,163	.96	20	2,183	14	12
Boundary			31.49	651	651	121,582	100,184
Butte			83.98	1,736	1,736	37,053	30,532
Camas			395.56	8,177	8,177	725	597
Cassia			30.82	637	637	1,998	1,646
Clearwater	839.26	17,349			17,349	187	154
Custer	84.66	1,750	3,146.79	65,050	66,800	232,319	191,431
Elmore	46.25	956	4,708.58	97,335	98,291	11,745	9,678
Fremont			.48	10	10	1,008	831
Gem	.68	14	.82	17	31	53	44
Gooding	1.64	34			34		
Idaho	522.88	11,429	9,698.94	200,495	211,924	5,050	4,161
Latah	13.11	271	1.79	37	308	52	43
Lemhi	2,002.56	41,397	881.07	18,213	59,610	159,994	131,835
Lincoln	4.69	97			97		
Nez Perce	.68	14			14		
Owyhee	.39	8	616.20	12,738	12,746	29,088	23,969
Power	11.27	233			233		
Shoshone	576.15	11,910	3,568.77	73,773	85,683	11,241,126	9,262,688
Twin Falls	12.14	251			251	1	1
Valley	2.95	61	36.38	752	813	756	623
Washington						168	138
	6,541.80	135,231	32,390.84	669,578	804,809	12,029,338	9,912,175

Mine production of gold, silver, copper, lead, and zinc in Idaho in 1917—Contd.

County.	Copper.		Lead.		Recoverable zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Ada	....	....	....	....	....	....	$5,887
Adams	31,080	$8,485	....	....	....	....	8,610
Benewah	....	....	....	....	....	....	3,201
Bingham	....	....	....	....	....	....	260
Blaine	19,416	5,301	1,710,133	$147,071	2,118,375	$216,074	507,491
Boise	4,323	1,180	43,821	3,769	....	....	242,852
Bonner	907	248	197,271	16,965	....	....	21,631
Bonneville	595	162	....	....	....	....	2,357
Boundary	704	192	6,514,134	560,216	....	....	661,243
Butte	31,570	8,619	2,559,908	220,152	....	....	261,039
Camas	....	....	4,490	386	....	....	9,160
Cassia	....	....	4,161	358	11,540	1,177	3,818
Clearwater	....	....	....	....	....	....	17,503
Custer	4,462,180	1,218,175	3,073,011	264,279	....	....	1,740,685
Elmore	241	66	1,333	115	....	....	108,150
Fremont	162,367	44,326	122,927	10,572	....	....	55,739
Gem	....	....	....	....	....	....	75
Gooding	....	....	....	....	....	....	34
Idaho	7,132	1,947	....	....	....	....	218,032
Latah	18,506	5,052	....	....	....	....	5,403
Lemhi	211,642	57,778	7,282,166	626,266	....	....	875,489
Lincoln	....	....	....	....	....	....	97
Nez Perce	....	....	....	....	....	....	14
Owyhee	....	....	8,407	723	....	....	37,438
Power	....	....	....	....	....	....	233
Shoshone	2,876,911	785,397	372,007,653	31,992,658	77,724,221	7,927,871	50,054,297
Twin Falls	....	....	....	....	....	....	252
Valley	....	....	....	....	....	....	1,436
Washington	....	....	30,106	2,589	....	....	2,727
	7,827,574	2,136,928	393,559,521	33,846,119	79,854,136	8,145,122	54,845,153

Producing placer mines and production of gold and silver in Idaho in 1916 and 1917.

County.	1916						1917					
	Hydraulic.	Dredge.	Drift.	Gold.	Silver.	Total value.	Hydraulic.	Dredge.	Drift.	Gold.	Silver.	Total value.
					Fine ounces.						*Fine ounces.*	
Ada	3	....	....	$2,659	30	$2,679	4	....	....	$5,512	57	$5,559
Benewah	2	....	....	8,105	46	8,135	2	....	....	3,182	23	3,201
Bingham	1	....	....	48	....	48	1	....	....	260	....	260
Boise	30	1	1	295,171	3,638	297,565	22	....	....	38,340	452	38,713
Bonneville	2	....	....	5,268	6	5,272	1	....	....	2,163	3	2,165
Canyon	4	....	....	1,708	15	1,718	....	....	....	....	....	....
Clearwater	15	1	....	26,112	268	26,288	8	1	....	17,349	187	17,503
Custer	7	....	....	4,121	86	4,177	6	....	....	1,750	33	1,777
Elmore	10	....	....	4,934	29	4,953	5	....	....	956	16	969
Gem	2	....	....	116	3	118	1	....	....	14	....	14
Gooding	4	....	....	243	....	243	1	....	....	34	....	34
Idaho	45	....	....	21,373	266	21,549	32	....	....	11,429	129	11,535
Latah	4	....	....	744	2	745	2	....	....	271	1	272
Lemhi	9	2	....	73,957	295	74,151	5	2	1	41,397	161	41,530
Lincoln	....	....	....	....	....	....	2	....	....	97	....	97
Nez Perce	1	....	1	41	....	41	1	....	....	14	....	14
Owyhee	4	....	....	185	5	188	1	....	....	8	....	8
Power	2	....	....	1,620	5	1,623	3	....	....	233	....	233
Shoshone	7	....	....	2,170	18	2,182	5	1	....	11,910	130	12,017
Twin Falls	4	....	....	518	....	518	3	....	....	251	1	252
Valley	....	....	....	....	....	....	2	....	....	61	1	62
	156	4	2	449,093	4,712	452,193	107	4	1	135,231	1,194	136,215

Ores sold or treated, deep mines producing, and average value of ores in Idaho.

County.	Ore sold or treated in 1917.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	Quantity.	Increase or decrease.	1916	1917	1916	1917	1916	1917
	Short tons.	*Short tons.*						
Ada	20	+ 20		2		$16.40		$16.40
Adams	165	− 711	6	3	$42.55	52.18	$5.30	.76
Bannock		− 57	3		40.67		2.12	
Bear Lake		− 62	3		22.64		.08	
Blaine	20,730	+11,617	44	31	18.54	24.48	7.11	6.71
Boise	27,590	+ 9,119	17	11	10.82	7.40	10.16	7.22
Bonner	781	− 949	8	2	22.18	27.70	13.66	5.66
Bonneville	2	+ 2		1		96.00		15.00
Boundary	38,591	+28,339	2	4	19.39	17.13	3.07	2.61
Butte	5,898	+ 5,898		8		44.26		5.47
Camas	999	+ 999		3		9.17		8.78
Cassia	147	− 5	3	2	60.58	25.97	22.49	15.53
Clearwater		− 15	1		11.13		11.13	
Custer	83,703	+ 5,376	21	27	20.33	20.77	2.29	3.06
Elmore	25,616	−13,669	5	8	5.08	4.18	5.08	4.18
Fremont	725	−10,949	8	3	24.22	76.88	2.06	1.16
Gem	4	− 353	4	1	7.85	15.25	7.72	15.25
Idaho	11,351	+ 4,603	27	24	16.25	18.19	16.22	18.02
Latah	59	+ 59		1		86.97		1.34
Lemhi	19,048	− 4,997	31	34	42.77	43.78	8.39	7.87
Owyhee	871	+ 315	17	17	37.82	42.97	37.82	42.14
Shoshone	2,522,127	+ 5,802	56	60	17.65	19.84	3.06	3.70
Valley	52	+ 52		4		26.42		26.42
Washington	28	+ 28		1		97.39		4.93
	2,758,507	+40,462	256	247	17.78	19.83	3.22	3.84

[a] Value per ton, placer product excluded.

Classifying the deep mines according to the metals produced in 1917 shows that there were 5 mines producing gold only; 1 silver only; 70 gold and silver; 5 copper only; 20 gold, silver, and copper; 54 gold, silver, copper, and lead; 2 gold, silver, copper, lead, and zinc; 14 gold, silver, and lead; 8 gold, copper, and lead; 27 silver and lead; 13 silver and copper; 15 silver, lead, and zinc; 7 gold, silver, lead, and zinc; 4 zinc alone; 1 lead and zinc; and 1 silver, copper, lead, and zinc.

REVIEW BY COUNTIES.

ADA COUNTY.

The Highland and Black Hornet districts produced $5.887 in gold and silver. This is largely represented by placer gold from the Monitor placer on Boise River.

ADAMS COUNTY.

Three deep mines produced 165 tons of ore, containing 152 ounces of silver and 31,080 pounds of copper, valued in all at $8,610. The ore had a total value per ton of $52.18 and was all copper ore.

Seven Devils district.—The production mentioned above came from the Seven Devils, River Queen, and Salzer Ford mines. This is a small production compared with former years.

BENEWAH COUNTY.

Two placer properties in Camas Cove district produced $3,182 in gold and 23 ounces of silver. Operations of the Cedar Creek property were stopped by litigation in July.

BINGHAM COUNTY.

Several miles east of Pingree, on Snake River, the Gold Point placer made a small production. Gold from the various Snake River districts was considerably less in 1917 than in 1916.

BLAINE COUNTY.

Mine production in Blaine County, Idaho, in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	44	9,113	$18,582	70,283	42,517	875,196	248,379	$168,958
1917	31	20,730	10,455	156,056	19,416	1,710,133	2,118,375	507,491
Increase or decrease, 1917		+11,617	−8,127	+85,773	−23,101	+834,937	+1,869,996	+338,533
Total, 1880-1917			2,465,858	15,574,163	209,801	181,576,964	6,508,007	24,907,429

There was a good increase in the county in the production of ore and of silver, lead, and zinc, but the output of gold and copper was less than in 1916. Thirty-one deep mines produced 20,730 tons of ore, which had a total value per ton of $24.48 and a value per ton in gold and silver of $6.71. The ore was divided into 10,456 tons of lead-zinc ore, 9,992 tons of lead ore, 262 tons of zinc ore, and 20 tons of siliceous ore. The majority of the ore, 14,874 tons, was concentrated, making 5,315 tons of concentrates valued at $416,390, or $78.34 per ton. There were 692 tons of crude ore shipped valued at $66,256, or $95.75 a ton. From 1880 to 1917 this county has produced $2,465,858 in gold, $14,078,177 in silver, $38,048 in copper, $7,812,303 in lead, and $513,043 in zinc, a total of $24,907,429. The output of the county by years to 1914 was published in this report[1] for that year. The boundary lines of Blaine County were considerably changed in 1917. The eastern section went to make up part of the newly established Butte County and part of the western section formed Camas County. The main producing area, including the Mineral Hill and Warm Springs districts, remains in Blaine County.

Galena district.—A small shipment of sulphide lead ore was made from the Timberline property, northwest of Ketchum.

Mineral Hill district.—Sixteen deep mines produced 1,261 tons of ore, $351 in gold, 22,389 ounces of silver, 2,232 pounds of copper, 258,724 pounds of lead, and 28,055 pounds of zinc, valued at $44,520, or $35.31 per ton. Part of the ore mined, 929 tons, was concentrated, and 330 tons were shipped directly to smelters. Numerous mines contributed small shipments; the most important came from the

---

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 613, 1915.

Eureka mine and the Red Elephant property. A 50-ton concentration mill on the latter property was active for a short time.

Vienna district.—A shipment of rich silver ore was made from the Vienna mine.

Warm Springs district.—Thirteen deep mines produced 19,444 tons of ore, containing $10,027 in gold, 131,006 ounces of silver, 17,135 pounds of copper, 1,443,726 pounds of lead, and 2,090,320 pounds of recoverable zinc, valued at $460,027, or $23.66 per ton. The production in 1916 was 6,547 tons of ore valued at $113,303. Most of the ore, or 13,945 tons, was concentrated, making 5,255 tons of concentrates. The material included 5,162 tons of slag and old tailings and 337 tons of ore shipped directly to smelters. The distinct increase in the district output was due to the North Star Triumph property, operated by the Federal Mining & Smelting Co. Lead-zinc ore and tailings were treated to make a lead concentrate and a lead-zinc concentrate. The recovery of concentrates has not been regular because the mill has been rearranged several times on account of the extreme complexity of the ore. The plant has a capacity of 120 tons and uses concentration on Wilfley tables followed by oil flotation. Considerable money has been spent in development and for the equipment of the property, the operating expense for 1917 alone being $98,652. Work was interrupted in February by a snowslide, which resulted in the death of 11 men.

A considerable production of lead resulted from the treatment of ore from the Independence mine. Concentrates from the 100-ton mill went to the United States smelter at Midvale, Utah. The product was rich in both lead and silver and contained about 20 per cent of iron. Toward the end of the year the property was leased and bonded by the Federal Mining & Smelting Co. A few shipments of carbonate zinc ore were made from the Lake Creek mines, operated by the Kusa Spelter Co. A considerable quantity of old slag was shipped from the Ketchum slag dump by the Big Four Exploration Co., of Salt Lake City, Utah.

BOISE COUNTY.

Mine production in Boise County, Idaho, in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	49	18,471	$470,060	23,161	23,260	92,356	$497,395
1917	33	27,590	217,486	24,778	4,323	43,821	242,852
Increase or decrease, 1917	....	+9,119	−252,574	+1,617	−18,937	−48,535	−254,543

[a] Includes placer production.

There was a very decided decrease, amounting to more than 50 per cent, in the output of gold in the county in 1917. Eleven deep mines produced 27,590 tons of ore, containing $179,146 in gold, 24,326 ounces of silver, 4,323 pounds of copper, and 43,821 pounds of lead, valued in all at $204,139, or $7.40 per ton. Of the ore, 26,251 tons were treated in gold and silver mills, and only 60 tons were shipped to smelters. Bullion in the ore milled was valued at $176,832, or $6.74 per ton in gold and silver. All of the output was siliceous, except 19 tons, which was lead ore. In 1917 there were 22 placer operators, who produced only $38,340 in gold and 452 ounces of silver, having a total value of $38,713. The large dredge of the Boston Idaho Co. was idle during 1917, which accounts for the decided decrease in the output of placer gold. In 1916 there were 32 placer mines, producing $295,171 in gold and 3,638 ounces of silver.

The production of gold and silver in the county, exclusive of copper and lead, from 1863 to the end of 1917 was $52,102,339 in gold and 2,151,866 ounces of silver, or a total value of $54,380,893. The output by years to 1914 was given in the report[1] for that year.

Banner district.—A 30-ton concentration mill, equipped with two Wilfley tables and a flotation plant, was put in operation in September, 1917, on siliceous silver ore from the Banner mine. Several shipments of rich concentrate and crude ore were made. It is planned to increase the capacity of the mill and to add a cyanide plant.

Boise Basin district.—Nineteen placers and 10 deep mines produced 26,270 tons of ore, $215,489 in gold, 4,700 ounces of silver, 4,078 pounds of copper, and 43,587 pounds of lead, valued in all at $224,224. Most of the ore was treated in gold and silver mills. This is a large decrease from the production of 1916, which was valued at $492,721. By far the most important producer was the Gold Hill & Iowa property. Ore was treated in a 75-ton plant using amalgamation and concentration, and the concentrates were cyanided. In 1917 this was the second largest gold producer in the State, the Holte mine in Idaho County being first. The National Mining & Development Co. treated considerable ore by cyanidation, and the Golden Age and Lucky Boy properties had some ore amalgamated. At the latter mine an electric power and light plant was installed and also a Marathon mill. Initial treatment, however, was not particularly successful. The Diana Mines Co., which did considerable development and advertising in 1915 and 1916, was in the hands of a receiver in 1917. Some bullion and concentrate were marketed in the early part of the year. At the Hay Fork mine, near Idaho City, a 25-ton Marathon mill was installed, which will be ready for operation in 1918. From the Mammoth property some ore was milled by amalgamation, and from the Mohawk mine a shipment of lead ore containing considerable gold was made. The most important of the 19 placer operators were the Boise Basin Improvement Co., the Granite Creek Ditch Co. or the Leary & Brogan ground, the Centerville Mining Co., and the Missouri Mining Co. The Pittsburg Idaho Hydraulic Mining Co. installed a hydraulic elevator in 1916, but the ground was so heavy that the equipment was replaced by a dry land dredge in 1917.

BONNER COUNTY.

Except in output of lead, there was a decided decrease in production in Bonner County in 1917. All of the production came from the Pend Oreille district and was that of the Lawrence Mining & Milling Co. and the B. F. & H. mine. The former produced lead ore, which was concentrated, and the latter a siliceous silver ore. Important development work was continued at the Keystone mine by the Armstead Mines (Inc.). A long adit was driven in record time and a large tonnage of silver milling ore opened. At the end of January, 1918, the vein was cut 3,565 feet from the portal at a depth of 1,600 feet, and ore was said to assay 25 ounces of silver per ton.

---

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 616, 1915.

BONNEVILLE COUNTY.

One deep mine and 1 placer produced gold, silver, and copper valued at $2,357. The placer production came from the hydraulic operations of the Idaho Mining & Dredging Co., at Gray, Idaho.

BOUNDARY COUNTY.

Four deep mines produced 38,591 tons of ore, containing $651 in gold, 121,582 ounces of silver, 704 pounds of copper, and 6,514,134 pounds of lead, valued in all at $661,243. Most of the ore, 37,856 tons, was concentrated and the remainder, 735 tons, was shipped directly to smelters. The ore had a total value per ton of $17.13 and a gold and silver value of $2.61. Practically all of it was lead ore.

Lenia district.—The Eureka mine, near Lenia, close to the Idaho-Montana boundary line, made a test shipment of sulphide lead ore.

Moyie Yahk district.—A small output of gold ore was shipped to the smelter by the Bethlehem Gold Mines (Ltd.), and preparations for extensive hydraulic work were said to be under way by the Idaho Gold & Ruby Mining Co.

Priest Lake district.—The greater part of the county output came from the Idaho Continental mine, west of Porthill. This important lead mine was operated for eleven months during the year and shipped several thousand tons of crude lead ore and concentrate. The 300-ton mill is equipped with crusher, rolls, jigs, classifier, Hardinge mill , Wilfley tables, and Frue vanners.

BUTTE COUNTY.

This county was formed during the year, principally from the northeastern part of Blaine County. It also includes parts of western Bingham County and Jefferson County. Eight deep mines produced 5,898 tons of ore, valued at $261,039. The total ore was classified as 5,744 tons of lead ore, 153 tons of copper ore, and 1 ton of siliceous ore. The ore had a total value of $44.46 per ton, of which the gold and silver value was $5.47.

Antelope district.—The Weiler group, under lease and bond, produced considerable oxidized lead ore.

Dome district.—The Wilbert Mining Co. operated a 100-ton concentration mill intermittently and made shipments of crude lead ore and concentrates of good grade. Though shipments were less in 1917 than in 1916 $50,000 in dividends were paid in 1917. This property was mentioned under Fremont County in this report for 1916. As the ore contains very little silver, the decrease in the price of lead had a serious effect on ore shipments, which have to be hauled 40 miles to railroad. The fiscal report[1] for the company mentions the increased costs and continues as follows:

---

[1] Wilbert Mining Co. (Ltd.) Ann. Rept. for year ending May 15, 1918.

It early became apparent to the present management that, in order to eliminate the increasing costs of handling the mine products by hoisting and transportation through various levels until the surface bins were reached, it would be necessary to sink a new shaft from the surface which would connect directly with and form an upward extension of the 200-foot winze sunk from the 600 level during the previous and present (fiscal) years * * *. At the present time the shaft is down 429 feet, at an angle of 21 degrees. An additional depth of 135 feet will connect it with an old stope below the 500 level and about 80 feet of this stope will have to be straightened to the angle of inclination above. The company will then have a straight incline shaft to a depth of 830 feet from which the ore body on the 800-foot level, and below, can be developed * * *.

To operate the drills necessary to sink this shaft a 50-horsepower Chicago pneumatic oil-driven compressor was installed together with a 6 by 8 inch hoisting engine, drills, etc. This installation was well suited for the purpose, though after the flow of water was developed on the 800 level it became apparent that still additional machinery would be necessary to carry on the development at greater depth. This machinery * * * has been ordered, some of it being now on the ground and in process of installation * * *.

The immediate object in the erection of this plant and the driving of a new shaft is, of course, the further development of the ore shoot which has been productive from the surface. * * *

During the year 44 lots of ore were settled for. Of this, 1,021 tons were direct shipping ore, while 3,125 tons of mill ore produced 893 tons of concentrates. This ore returned the company $69.77 per ton or a total of $133.477.31.

With the present price of lead and with cheaper methods of ore extraction available by reason of the new shaft and hoisting machinery, the ore on the 800-foot level, which can readily be blocked out as soon as the new improvements are perfected, should show a substantial profit. From present progress it is probable that shipping will be resumed by the middle or latter part of July.

Hamilton district.—Three deep mines produced 1,032 tons of ore, $1,158 in gold, 2,482 ounces of silver, 11,827 pounds of copper, and 204,365 pounds of lead, valued in all at $24,008, or $23.26 per ton. A shipment of copper ore came from the Copper & Uranium property, and lead ore from the Frank mine and the Metta property.

CAMAS COUNTY.

The western part of Blaine County, including the locality around Soldier, was formed into Camas County in 1917. Three deep mines produced 999 tons of ore, $8,177 in gold, 725 ounces of silver, and 4,490 pounds of lead, valued in all at $9,160. A small production of sulphide lead ore came from the Square Deal property in the Rosetta district. Nearly all the remainder of the ore came from the El Oro Mines (Ltd.), which operated a 10-stamp amalgamation and concentration mill a little over a month. Considerable bullion and rich gold concentrate were shipped. The mill at the Cannon Ball mines in Little Smoky district was improved by adding rolls and jigs, and a K. & K. flotation machine will be installed.

CASSIA COUNTY.

In the Black Pine district, the Hazel Pine mine produced a few shipments of ore containing gold, silver, and lead, the greatest value being for the silver. A shipment of carbonate zinc ore came from the Deer Ridge property. At the Melcher mine, in the Stokes district, a 100-ton concentration plant was under construction.

CLEARWATER COUNTY.

Nine placers produced $17,349 in gold and 187 ounces of silver, valued in all at $17,503. The output in 1916 was valued at $26,455.

Burnt Creek district.—Placer gold and silver valued at $442 came principally from the Sweepstake placer.

Pierce district.—The placer output had a value of $17,061, against an output valued at $25,437 in 1916. The majority of the output came from the operation of the dredging plant of the Pierce Co. (Ltd.).

CUSTER COUNTY.

Twenty-seven deep mines produced 83,703 tons of ore, an increase of 5,376 tons. The production of the county, including the output of 6 placers, was $66,800 in gold, 232,319 ounces of silver, 4,462,180 pounds of copper, and 3,073,011 pounds of lead, in all valued at $1,740,685. Other than Shoshone County, this is the only county in the State that produced metals valued at more than a million dollars, although the output of Lemhi County was close to this amount. The county output in 1916 was valued at $1,596,789. The ore was divided into 68,832 tons of copper ore, 13,670 tons of lead ore, and 1,201 tons of siliceous ore. Most of the product was crude ore shipped to the smelters, 82,146 tons, valued at $1,686,217, or $20.53 per ton. No ore was directly concentrated, but 1,201 tons of ore were treated in gold and silver mills making bullion and 62 tons of rich gold concentrate.

Alder Creek district.—This is the most important producing area in the county. There were 14 deep mines producing 80,886 tons of ore, containing $53,428 in gold, 152,308 ounces of silver, 4,386,575 pounds of copper, and 2,356,785 pounds of lead, valued in all at $1,579,148, or $19.54 per ton. All of the product was crude shipping ore. In 1916 twelve mines in the district produced 77,288 tons of ore valued at $1,563,744. The Empire Copper Co., the largest producer, continued to ship copper ore at the rate of more than 5,000 tons a month. This mine alone produced more than half the copper in the State. Dividends declared in 1917 amounted to $200,000. The lower or Cossack tunnel was being connected with the Alberta tunnel above, and a tramway 3 miles long, planned to carry 50 tons per hour, was being installed. Shipments, however, were curtailed, as the Salt Lake smelters were unable to take care of the increased quantity of ore shipped from various districts.

Shipments of copper ore were also made by the Copper Basin Mining Co., but the quantity was much less than in 1916. The company was said to be working on a large body of low-grade sulphide ore newly discovered. There were two other important mines in the district, the Horseshoe property and the Homestake & Copper Queen mine, both producing lead carbonate ore. The latter property averaged nearly 1,000 tons a month during 1917. In the early part of 1918 it was bonded by the United States Smelting Co., of Salt Lake City, Utah.

The geology of this region is described in a recent Survey publication.[1]

---

[1] Umpleby, J. B., Geology and ore deposits of the Mackay region, Idaho: U. S. Geol Survey Prof. Paper 97, 1917.

Bay Horse district.—Nine deep mines produced 1,613 tons of ore, $178 in gold, 76,449 ounces of silver, 75,605 pounds of copper, and 712,717 pounds of lead, valued in all at $145,106, or $89.96 per ton. The output in 1916 was valued at $12,666. The largest production came from the operations of a lease on the Red Bird property belonging to the Clayton Mining & Smelting Co. Several hundred tons of oxidized lead ore were shipped. Shipments of lead ore were also made from the Riverview mine, belonging to the Aetna Mining & Investment Co. The Ramshorn mine, operated by the same interests, produced copper sulphide ore and some old smelter material containing principally silver and copper.

Stanley Basin district.—The output of the district was comparatively low. Only 4 placers produced $1,164 in gold and 30 ounces of silver. The Challis & Sturkey property was operated about six weeks.

Yankee Fork district.—Two deep mines and 2 small placers produced 1,201 tons of ore, $12,030 in gold, and 3,360 ounces of silver, both valued at $14,798. The only important producer was the Old Montana group, belonging to the Custer Consolidated Mining & Development Co. Several hundred tons of ore were treated by amalgamation and concentration.

ELMORE COUNTY.

Eight deep mines produced 25,616 tons of ore, a decrease of 13,669 tons. The value of the ore per ton decreased from $5.08 in 1916 to $4.18 in 1917. The total output of the county, including that of five placers, was $98,291 in gold, 11,745 ounces of silver, 241 pounds of copper, and 1,333 pounds of lead, valued in all at $108,150. The placer output was $956 in gold and 16 ounces of silver.

Bear Creek district.—From 1 small placer and 2 deep mines the district produced gold and silver valued at $396.

Highland district.—A small placer production came from the Last Chance property, near Barber.

Middle Boise district.—Two placers and 4 deep mines produced 25,590 tons of ore, $97,202 in gold and 11,593 ounces of silver, valued in all at $106,755. This represents a decrease from 38,558 tons of ore and a total value of $194,384 in 1916. All of the ore but 10 tons was treated in gold and silver mills. The greater part of the production came from the Boise Rochester mine, where a 40-stamp mill using amalgamation and concentration was operated. A Callow flotation cell was used after the Wilfley tables. The plant was operated from January to the end of September, 1917, when the property was optioned to the new owners. The Atlanta Mines Co. treated several thousand tons of low-grade ore by amalgamation and cyanidation. The property is equipped with five 5-foot Huntington mills and uses plate amalgamation, table concentration, and roasting and cyaniding of concentrates.

Pinegrove district.—An output of gold ore was marketed from the property of the Daily Consolidated Mining Co.

FREMONT COUNTY.

The production of this county is small because part of its mineral area went to make up Butte County in 1917. Three deep mines produced 725 tons of ore. The total value per ton was $76.88, and the gold and silver value $1.16. There were 509 tons of copper ore and 216 tons of lead ore.

Skull Canyon district.—The Skull Canyon mines produced several hundred tons of oxidized copper ore, smelted near Salt Lake City, Utah.

GEM COUNTY.

West View district.—The production from a small shipment of gold ore and a little placer bullion was valued at $75. The district produced metals valued at $2,921 in 1916, and was an important producer several years ago.

IDAHO COUNTY.

Mine production in Idaho County, Idaho, in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	
1916	72	6,748	$129,322	2,572	739	$131,197
1917	56	11,351	211,924	5,050	7,132	218,032
Increase, 1917		4,603	82,602	2,478	6,393	86,835

[a] Includes placer production.

Twenty-four deep-mine operators produced 11,351 tons of ore, an increase of 4,603 tons. The value per ton of the output increased from $16.25 in 1916 to $18.19 per ton in 1917, nearly all of which was for gold and silver. The total output of the county, including that of 32 placers, was valued at $218,032. The placer output was $11,429 in gold and 129 ounces of silver, valued in all at $11,535. Nearly all of the ore, or 11,154 tons, was treated in gold and silver mines, resulting in bullion valued at $202,386, or $18.14 per ton. The remainder of the ore, 197 tons, was shipped directly to smelters.

Camp Howard district.—Three small placers produced $1,090 in gold and eight ounces of silver. The Cape Horn property was the main producer.

Clearwater district.—Aside from a small placer production, the principal operations were on the Cunningham property, from which several shipments of siliceous gold ore, containing some copper, were made.

Dixie district.—A small placer output came from the Moore property, and some gold ore was treated by amalgamation from the Powelson mine.

Elk City district.—Five placers and 9 deep mines produced 839 tons of ore, $9,961 in gold and 130 ounces of silver, having a total value of $10,068. These totals represent a decrease from 1,433 tons of ore and an output valued at $23,778 in 1916. The placer product was valued at $3,453. Bullion from ore amalgamated was marketed from the Mineral Zone, Black Pine, Grangeville, Hope, and Spiked Horse properties. The principal producing placer was the Golden Rule property.

Marshall Lake district.—The production came from the Sherman & Corporal property, known as the Holte mine, and the Lake Creek placer, both near Burgdorf. As the Holte property is the most important gold mine in Idaho, judged by the output in 1917, it is unfortunate that the management publishes no report concerning its operations. Several thousand tons of ore were treated in a 30-ton amalgamation plant equipped with a Lane mill and Deister tables. In October, bullion valued at $24,000 was shipped, and this was said to be a month's clean-up. Late in the year a cyanide plant was being installed. In the same district it was reported that development at the Mount Marshall mine had opened ore at a depth of 1,600 feet.

Newsome district.—Two placers and 2 deep mines produced $557 in gold and 4 ounces of silver. The Moose Creek placer was operated for a short time.

Orogrande district.—The Oro Grande Gold Mining Co. completed a 240-ton cyanide plant on the Crooked River property, but practically no bullion was recovered during the year. A large but low-grade deposit of gold ore is opened by adits and crosscuts.

Ten Mile district.—Six placers and 4 deep mines produced 473 tons of ore, $8,141 in gold, and 135 ounces of silver, total value being $8,252. The output in 1916 was valued at $24,395. Operations continued at the New York mine, but on a smaller scale, and also at the Lone Yellow Pine property. Fair productions came from the Crescent, Little Leggett, Phoenix, and Tippie placers.

Warren district.—Eight placers and 4 deep mines produced 1,038 tons of ore, $12,441 in gold, and 431 ounces of silver, having a total value of $12,796. The output in 1916 was valued at $34,749. The principal producer was the Idaho Standard Mines Co., but the bullion shipped was less than it was during each of the last three years. There were no important placer operations in the district.

Unorganized district.—The Fisher placers produced some gold by hydraulic methods from the South Fork of Clearwater River, near the mouth of Meadow Creek.

KOOTENAI COUNTY.

No production was reported, but development was progressing at the Commonwealth property, near Hayden Lake. Considerable milling ore, containing silver, copper, and lead, is opened.

LATAH COUNTY.

One deep mine and 2 small placers produced gold, silver, and copper, valued at $5,403. Several shipments of copper ore came from the Merger property, operated by the Cottonwood Mining Co.

LEMHI COUNTY.

Mine production in Lemhi County, Idaho, in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	42	24,045	$113,070	247,571	216,333	11,208,985	$1,102,610
1917	42	19,048	59,610	159,994	211,642	7,282,166	875,489
Decrease, 1917	....	4,997	53,460	87,577	4,691	3,926,819	227,121

[a] Includes placer production.

There was a general decrease in this county in 1917. Thirty-four deep mines produced 19,048 tons of ore, a decrease of 4,997 tons. The total value of the ore was $43.78 per ton, and $7.87 for the gold and silver content. Eight placers produced gold valued at $41,397 and 161 ounces of silver, valued in all at $41,530. The placer output in 1916 was valued at $74,151. Two dredges were operated during the year, but the shipments of bullion were less than in 1916. Most of the ore, or 17,183 tons, was shipped directly to the smelters, and had a total value of $819,596, or $47.70 per ton. There were 1,617 tons of ore treated in gold and silver mills valued at $3,553, and 248 tons were concentrated, making 62 tons of concentrates, valued at $10,810. The ore was classified as 16,528 tons of lead ore, 1,653 tons of siliceous ore, and 867 tons of copper ore.

Eldorado district.—One placer and 7 deep mines produced 612 tons of ore, $5,408 in gold, 475 ounces of silver, and 85,571 pounds of copper, valued in all at $29,161. The dredge of the Bohannon Co. was not operated, but some gold was won from the deposit by hydraulic mining. Small shipments of copper ore were made from several new properties in the district. The largest producer was the Harmony Mines Co., which made good shipments of sulphide copper ore. An oxidized ore was shipped from the Pope Shenon mine. Other producers were the Ranger, Ruby, and Gold Point properties.

Eureka district.—The Mullen dredge on Moose Creek and Daly Creek was operated for about four months during the year. A little ore from the Wickham mine was treated by amalgamation.

Indian Creek district.—The Kittie Burton property, formerly an important producer, made only a few shipments of gold bullion during 1917. The property is equipped with an old 15-stamp amalgamation plant, but only 5 stamps were used intermittently during the year.

Junction district.—A good quantity of sulphide lead ore was shipped from the Sunset property, formerly called the Junction mines. One shipment of copper ore was made by the Greenback Copper Co.

Kirtley Creek district.—The Kirtley Creek Gold Dredging Co. operated its plant during 10 months of the year, and treated 740,587 cubic yards of material. As the Boston-Idaho dredge at Idaho City was idle, this was the most important dredge operation of the year.

Mackinaw district.—Three placers in this district produced $2,192 in gold and 8 ounces of silver. The Hockensmith placer on Arnett Creek was the largest producer.

McDevitt district.—A few shipments of copper concentrates were made from the Copper Queen property, operated by the Idaho-Seattle Mining Co. A small concentration plant was active only during a short period. Some crude ore was also shipped from the Blue Bird claim.

Mineral Hill district.—Four deep mines produced 771 tons of ore, $1,954 in gold, and 58 ounces of silver, having a total value of $2,002. The output in 1916 was valued at $3,899. Most of the ore came from the Kentuck property, on which the mill is equipped for amalgamation and concentration, but the concentrates were not marketed.

Pratt Creek district.—A small quantity of ore from the Climax property was treated by amalgamation. The mill was improved by the addition of a Dorr classifier, a Card table, and a Wilfley table.

Spring Mountain district.—Eight deep mines produced 640 tons of ore, $876 in gold, 5,698 ounces of silver, 5,615 pounds of copper, and 305,306 pounds of lead, valued in all at $33,360, or $52.13 per ton. In 1916 the output was valued at $31,933. The entire output was an oxidized lead ore smelted in Utah. The principal part of it came from the Winnie mine, owned by the Excelsior Mining Co.

Texas district.—Eight deep mines produced 13,995 tons of ore, $10,015 in gold, 138,105 ounces of silver, 83,456 pounds of copper, and 6,516,418 pounds of lead, valued in all at $707,008, or $50.52 per ton. The entire product was oxidized lead ore shipped without treatment. In 1916 eight deep mines produced 20,384 tons of ore valued at $953,722. The largest producer was the Pittsburg-Idaho Co., followed by the Latest Out Mining Co., and the Gilmore Mining Co. Shipments were also made from the Mountain Boy mine. The Pittsburg-Idaho mine shipped about 500 tons per month in 1917, against 1,000 tons per month in 1916. Dividends of $65,524 were paid from previous earnings remaining at the close of 1916, but the mine was said to be closed at the end of 1917. The loss in 1917 was due to transportation difficulties, water in the mine, and delay in the delivery of power machinery. Shipments from the Latest Out mine were at the rate of 300 tons per month, practically the same as in 1916, and the Gilmore Mining Co. shipped approximately 250 tons per month.

OWYHEE COUNTY.

Mine production in Owyhee County, Idaho, in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Lead.	Total value.
		Short tons.		*Fine ozs.*	*Pounds.*	
1916	21	556	$10,344	16,513	....	$21,209
1917	18	871	12,746	29,088	8,407	37,438
Increase, 1917	....	315	2,402	12,575	8,407	16,229

[a] Includes placer production.

Seventeen deep mines produced 871 tons of ore, an increase of 315 tons. The ore had a total value per ton of $42.97 and a gold and silved value of $42.14. The entire product was siliceous. The production of gold and silver from the discovery of gold in 1863 to and including that of 1917 was $21,643,604 in gold and 24,379,782 ounces of silver, having a total value of $40,424,125. There was only one small placer operated in 1917.

Carson district.—Nearly all the county output came from this district. The gold was valued at $12,738, which with 29,088 ounces of silver and 8,407 pounds of lead, gave a total value of $37,430, or $42.97 per ton. The most important part of the production came from the Sunnyside mine, operated by the Bergh Mining Co. Amalgamation and concentration were used in the mill, which was operated for a short time. The Trade Dollar property, owned by the Florida Mountains Mines Co., produced some gold and silver as a result of ore milled and some rich crude ore and concentrates shipped. At the Silver City property several hundred tons of siliceous silver ore were treated by cyanidation. A small clean-up was made from the old De Lamar mine.

Steele district.—In the Steele district, the Demming Mines Co. erected a 100-ton flotation plant on Boulder Creek, 40 miles southwest of Murphy, Idaho. It consists of crusher, tube mill, classifier, flotation machines, and filter, to treat ore containing gold and silver. Machinery is also on the ground to increase the capacity to 200 tons per day.

POWER COUNTY.

A small placer production came from the banks of Snake River near Aberdeen, American Falls, and Neeley.

SHOSHONE COUNTY.

Mine production in Shoshone County, Idaho, in 1916 and 1917.

Year.	Num-of pro-producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	63	2,516,325	$46,459	11,639,841	2,370,610	356,233,926	86,238,283	$44,424,716
1917	66	2,522,127	85,683	11,241,126	2,876,911	372,007,653	77,724,221	50,054,297
Increase or decrease, 1917	....	+5,802	+39,224	−398,715	+506,301	+15,773,727	−8,514,062	+5,629,581

[a] Includes placer production.

Shoshone County is usually referred to as the Coeur d'Alene region, which is the most important mining center of the State. It comprises several mining districts, the production of each of which is given separately. Sixty deep mines in the county produced 2,522,127 tons of ore, an increase of 5,802 tons over the output of 1916, when 56 deep mines produced. The total value per ton of the ore as mined was $19.84 and the value per ton in gold and silver was $3.70. The corresponding values in 1916 were $17.65 and $3.06. The value of the county output increased nearly 13 per cent and represented more than 91 per cent of the total value of the State output. There was a good increase in the production of lead, and small increase in both copper and gold, but the production of zinc and silver decreased. The output of lead ore ranked first with 1,362,745 tons, and lead-zinc ore followed closely with 1,107,619 tons. There were also 32,614 tons of copper ore, 18,987 tons of zinc ore, and 158 tons of siliceous ore. More than 84 per cent of the total ore of the State (2,317,949 tons) and 24,854 tons of old tailings were concentrated and reduced to 407,609 tons of concentrates, containing $34,826 in gold, 7,770,764 ounces of silver, 1,290,226 pounds of copper, 278,132,199 pounds of lead, and 63,756,334 pounds of recoverable zinc, in all valued at $37,212,682, or $91.05 per ton. These concentrates were separated into 1,308 tons of copper concentrates, containing 39.57 ounces of gold, 29,084 ounces of silver, and 438,275 pounds of copper; 182,922 tons of lead concentrates, containing 1,029.01 ounces of gold, 4,186,357 ounces of silver, 511,143 pounds of copper, and 161,975,139 pounds of lead; 15,245 tons of zinc concentrates, containing

46,805 ounces of silver, 830,640 pounds of lead, and 10,066,224 pounds of recoverable zinc; and 76,554 tons of lead-zinc concentrates, containing 47 ounces of gold, 288,282 ounces of silver, 9,448,459 pounds of lead, and 53,690,110 pounds of recoverable zinc. In 1917 only a few tons of ore were treated by amalgamation or cyanidation, but there were 32 milling plants having a combined daily capacity of approximately 10,372 tons, which were active nearly all of the year. These mills were concentration plants, and 24 of them used flotation machines. Of the county ores treated or shipped 179,323 tons were first-class crude ore containing $38,931 in gold, 3,470,232 ounces of silver, 1,586,685 pounds of copper, 93,875,454 pounds of lead, and 13,967,887 pounds of recoverable zinc, in all valued at $12,829,580, or $71.54 per ton. The crude ore smelted included 157 tons of siliceous ore, 8,487 tons of copper ore, containing 1,220.33 ounces of gold, 76,615 ounces of silver, and 1,010,404 pounds of copper; 148,672 tons of lead ore, containing 641.95 ounces of gold, 3,341,978 ounces of silver, 575,961 pounds of copper, and 92,212,556 pounds of lead; 12,372 tons of zinc ore, containing 11,481 ounces of silver, 587,456 pounds of lead, and 9,960,963 pounds of zinc; and 9,631 tons of lead-zinc ore, containing 14 ounces of gold, 39,355 ounces of silver, 1,074,594 pounds of lead, and 4,006,924 pounds of zinc. Six placer mines in the county produced $11,910 in gold and 130 ounces of silver.

Some recent articles referring to the region are noted below.

Easton, S. J., The Coeur d'Alene district: Eng. and Min. Jour., Jan. 12, 1918, p. 64.

Bell, R. N., Mining industry of Idaho for 1917; Idaho Geol. Survey Nineteenth Ann. Rept., 1918.

Soper, E. K., Mining districts of northern Idaho; Min. and Sci. Press, Jan. 26, 1918, p. 121.

American Smelting v. Bunker Hill: Min. and Sci. Press, Dec. 1, 1917, p. 779.

Mine production in the Coeur d'Alene region, Shoshone County, Idaho, 1884–1917.

Year.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Fine ounces.	*Pounds.*	*Short tons.*	*Pounds.*	
1916	46,459	11,639,841	2,370,610	178,117	86,238,283	$44,424,716
1917	85,683	11,241,126	2,876,911	186,004	77,724,221	50,054,297
1884–1917	5,608,399	165,108,762	68,054,429	2,647,377	334,651,441	409,935,329

Since the beginning of mining in 1884 the Coeur d'Alene region has produced gold, silver, copper, lead, and zinc valued at $409,935,329—gold, $5,608,399; silver, $102,424,182; copper, $10,935,462; lead, $257,188,290; and recoverable zinc, $33,778,996. The production of this region by years, from 1884 to 1913, was given in the report for 1913.[1] From 1904 to 1917 the operators in the region mined, shipped or treated 26,710,555 tons of ore.

Beaver district.—Four deep mines and 4 placers had a total production of 151,941 tons of ore, $1,314 in gold, 284,967 ounces of silver, 1,129 pounds of copper, 15,383,920 pounds of lead, and 44,796,575 pounds of recoverable zinc, valued in all at $6,128,703. In

---

[1] U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 780, 1914.

1916 the mines produced 146,407 tons of ore, which, with the placer output, had a total value of $8,261,950. Of the total quantity, 138,004 tons were milled, making 54,350 tons of concentrates, and 13,937 tons were shipped directly to smelters. Lead ore was milled from the Idora and the Tuscumbia mines, and lead-zinc ore from the Ray Jefferson mine was treated in a new 400-ton concentration plant. As usual, the greater part of the district output was from the property of the Consolidated Interstate-Callahan Mining Co., the largest zinc producer in the State. The printed report of the company,[1] made for 18 months so as to change to the calendar year, contains the following paragraphs:

> During the period covered by this report we have completed the 3-compartment shaft to what is known as the No. 8 level, a distance of 850 feet below the main working tunnel, or the No. 4 level. We have developed and have been mining from a fine body of ore on the No. 7 level, and have encountered the same high-grade ore on the No. 8 level, which is just opened up, proving that the ore is continuing with depth. The shaft is being continued to what will be known as the No. 9 level, which will give the mine a depth of 1,050 feet below the main workings of the property. * * *
>
> During the last 18 months several important additions to our milling equipment have been installed. These improvements consist of a 400-ton flotation plant, a Sauerman slack-line cableway, and the enlargement of our grinding, thickening, and flotation departments to meet the demands of an increasing tonnage. * * *
>
> Our company has acquired a controlling interest in the Blue Grouse Mining Co. and also a controlling interest in the Silver State Mining Co., which properties adjoin the Interstate property on the north. We have also acquired full ownership of the Nipsic property, which adjoins the Silver State property. These three additional properties increase the acreage of the Consolidated Interstate-Callahan Mining Co. by approximately 342 acres, giving our company a total acreage at this time of 1,250 acres. A crosscut is now being run from the Interstate No. 6 level, across the Silver State property and into the Nipsic property, which will open up the Nipsic vein about 1,000 feet below the ore body indicated in the upper levels of the Nipsic mine, and will also develop the Silver State property.
>
> During the year our title to the Amazon-Manhattan property, which was acquired by the company some years ago, was questioned by adverse claimants, and the matter went to the State courts of Idaho for adjustment, which resulted in the courts directing that the adverse claimant be awarded the property, upon the return to the company of the full amount paid for the Amazon-Manhattan—that is, $160,000. * * *
>
> Conditions at the mine and in the mill are first-class, and when the new flotation plant is thoroughly adjusted we expect to make a much higher recovery of metal values in the ore. * * *
>
> Notwithstanding the unsettled labor conditions with which other sections of the country have had to contend, so far we have had no labor troubles of any kind in the Coeur d'Alene district.

A summary of the quarterly reports gave 161,455 tons of ore mined, of which 130,724 tons were milled. The crude ore and concentrates shipped amounted to 67,008 tons. The lead in lead ore and lead concentrate was 8,956,100 pounds, and the gross zinc in crude zinc ore and concentrate was 52,045,288 pounds. There was also silver recovered from both the lead and the zinc products and some lead from the zinc products. According to the statement to the county assessor the product had a gross value of $3,250,835. The cost of extraction was $1,080,698; freight and treatment, $747,375; betterment and repairs, $188,699; and net profit, $1,234,063. Dividends declared in 1917 amounted to $929,980, making $6,509,860 to date.

---

[1] Consolidated Interstate-Callahan Mining Co. Rept. for 18 months ending Dec. 31, 1917.

A small placer production from the district was valued at $1,231, partly from the Lock & Erwin property on Trail Creek.

Coeur d'Alene district.—On Prichard Creek, near Murray, stream gravel was treated by the dredge of the Yukon Gold Co. This plant was brought from Alaska and operated about one month toward the close of the year. It is of steel construction, electrically driven, and will treat about 5,000 cubic yards of gravel per day. In 1918 it will probably add much gold to the State output.

Eagle district.—A considerable quantity of lead sulphide ore of good grade was shipped from the Jack Waite property to the lead plant at International, Utah. In November shipments ceased as floods had made the roads impassable.

Evolution district.—Six deep mines produced 4,456 tons of ore, $766 in gold, 163,037 ounces of silver, 26,275 pounds of copper, and 735,431 pounds of lead, valued in all at $205,529, or $46.12 per ton. The output in 1916 was valued at $38,353. Several properties were operated, including the Old Charles Dickens, Nellie, Polaris, and Silverado. The best part of the ore came from the Yankee Boy mine, operated by the Big Creek Leasing Co. A considerable quantity of ore high in silver but rather low in lead was shipped to the East Helena smelter. Dividends of $10,000 were paid in 1917.

Hunter district.—Nine deep mines produced 585,903 tons of ore, $10,348 in gold, 1,766,441 ounces of silver, 361,234 pounds of copper, 70,448,635 pounds of lead, and 7,145,620 pounds of recoverable zinc, valued in all at $8,351,948, or $14.25 per ton. In 1916 seven deep mines had an output valued at $6,793,627. Most of the ore, or 508,674 tons, together with 8,390 tons of old tailings, was milled and made 56,700 tons of concentrates, containing 205.57 ounces of gold, 1,055,459 ounces of silver, 308,383 pounds of copper, 39,291,048 pounds of lead, and 7,123,180 pounds of recoverable zinc. The remainder was crude ore shipped to smelters—68,839 tons—containing 295 ounces of gold, 710,982 ounces of silver, 52,851 pounds of copper, 31,157,587 pounds of lead, and 22,440 pounds of recoverable zinc. The largest producer was the Morning mine, owned by the Federal Mining & Smelting Co., which was operated 11 months during the year. According to the statement to the county assessor, the mine produced 469,079 tons of ore extracted, having a gross value of $4,620,345. The cost of extraction was $1,668,772; freight and treatment, $1,463,366; betterment and repairs, $168,248; and net profit, $1,319,962. The printed annual report[1] of the company, which deals with the Morning mine and mines in other districts, contains the following notes:

> The amount of ore shipped during the year, while slightly less than that shipped during the preceding year, is greatly in excess of that shipped in 1915: Total shipments 1917, 130,097 tons; 1916, 137,390 tons; 1915, 75,449 tons.
>
> During the year, the profitable mines of the company yielded the following profits: Wardner, $54,884; Morning, $1,319,892; Mace, $272,162. * * *
>
> *Mace mines.*—The profitable ore in both Green Hill and Federal territory was exhausted in December, 1917, and the property is now shut down. The pumps have been brought to the surface and stored, and the other machinery dismantled. * * *
>
> *Wardner mine.*—This mine is practically exhausted and will probably be finally closed down within the year. It will not thereafter be a producer, as title to the property will then finally vest in the Bunker Hill & Sullivan Mining & Concentrating Co. under the terms of the settlement of 1910.

---

[1] Federal Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1917.

Morning mine.—Developments during last year were very satisfactory. The 2,000 level has been sunk and has disclosed much additional ore. The mine seems to grow better with depth.

Due to a shifting or swelling of the side walls, the Morning shaft became badly in need of repairs, necessitating the closing down of the mine from early in December until the middle of February, when operations were resumed. During the period of shutdown many of the crew sought employment elsewhere, but it is expected that in a short time the mine will again be running to its full capacity. * * *

The total ore mined by the company was 728,359 tons, but this total included 50,500 tons from the Greenhill mine and 7,360 tons from the North Star in Blaine County. Ore reserves January 1, 1918, at the Wardner, Morning, and Mace mines were 637,870 tons of milling ore and 89,595 tons of first-class ore.

The average number of employees at all plants, exclusive of the Wallace office, was 1,064, at an average wage of $4.98 per shift. * * *

The efficiency of labor measured in tons of ore per man per shift is only 75 per cent of that of normal times, say 1914. Wages have increased 32.4 per cent over normal. The increased cost of labor to us is, therefore, 76.6 per cent.

The costs of materials and supplies have also continued to increase all along the line, especially powder and steel. * * *

The company's operations are now substantially confined to the Morning mine, which contains a large body of complex ore. Our milling and metallurgical processes have been greatly improved in the last year or two. Nevertheless, with advancing costs of labor and supplies and a fixed maximum to the price of lead, profits become uncertain and difficult to forecast. * * *

During the year a suit was brought by the Star Mining Co. against the Federal Co. for an injunction and accounting in regard to the Morning vein lying west of the west-end line of the Morning. A temporary injunction was granted, which suspended operations during the year in the ground in dispute, and considerably curtailed the activity of the Morning mine. In addition, the necessity for doing a large amount of development work to prove our case in court resulted in a material decrease in the development of the Morning mine proper. However, this litigation work resulted in the disclosure of a much larger amount of ore in the ground in dispute than we had previously estimated, and resulted, as a whole, in a material addition to our ore reserves of the Morning mine. The estimated tonnage in this ground is about 654,000 tons.

The Star case was tried the latter part of the year 1917, and a decision has just been rendered in favor of the contention of this company.

The Gold Hunter Mining & Smelting Co. operated its mine and mill throughout the year. The plant has a capacity of 400 tons per day, and is equipped with ball mill, Dorr thickener, and three flotation cells. Concentrates which were shipped to Colorado contained slightly more lead but less silver than in the output of 1916. According to the statement to the assessor 116,562 tons were extracted, having a gross value of $994,408. The cost of extraction was $525,494; freight and treatment, $293,202; betterment and repairs, $44,893; and net profit, $130,812. No dividends were paid.

At the National property several thousand tons of ore were treated in the 500-ton concentrator. Shipments of copper concentrates were made to Tacoma. The management has had considerable difficulty with a low-grade ore in a very hard gangue, but shipments are continuing in spite of adverse conditions. According to the county assessor there were 13,374 tons of ore extracted, having a gross value of $72,742. The cost of extraction was $41,835; freight and treatment, $15,720; and betterment and repairs, $50,000.

A few shipments of copper ore were made from the Snowstorm property, east of Mullan, formerly the largest producer of copper in the State.

The North Idaho Metals Corporation treated old tailings and separated and shipped lead concentrate and lead-zinc concentrate. Small shipments were made from the Alice, Carney, and Midnight properties.

Lelande district.—Nine deep mines produced 802,479 tons of ore, containing $15,610 in gold, 5,170,490 ounces of silver, 552,180 pounds of copper, 142,601,428 pounds of lead, and 3,535,684 pounds of recoverable zinc, valued in all at $17,051,202, or $21.25 per ton. The output had a value greater than that of any district in the State, though the output of Yreka district was nearly as large. The production of lead was considerably greater than in any other district in the State. In 1916 the output of the district was valued at $15,512,333. Of the ore, 747,734 tons, with 733 tons of old tailings, were concentrated, making 123,090 tons of concentrates, containing 535.14 ounces of gold, 3,500,260 ounces of silver, 309,308 pounds of copper, 98,651,367 pounds of lead, and 2,747,335 pounds of recoverable zinc. The crude ore shipped was 54,012 tons, containing 220 ounces of gold, 1,670,230 ounces of silver, 242,872 pounds of copper, 43,950,051 pounds of lead, and 788,349 pounds of recoverable zinc. As in former years, the main producer of the district was the Hercules mine, from which more than 2,000 tons of first-class crude ore were shipped per month. In addition to these shipments, the mill at Wallace treated more than 900 tons per day throughout most of the year. The product is mainly a lead sulphide crude ore and concentrate shipped to the Northport Smelting Co., at Northport, Wash. There is, however, some zinc ore shipped and some zinc concentrate saved at the mill. Details concerning the mining and milling operations of the company are not published. According to the statement to the assessor, 108,052 tons of crude ore and concentrate were shipped, having a total value of $9,880,979. The cost of extraction was $2,140,053; freight and treatment, $3,765,025; betterment and repairs, $285,500; and net profit, $3,690,400. Dividends were paid, but the amount paid was not published. An estimate in the Wallace Miner was $3,000,000 for the year. As a result of a lawsuit in 1917, the following information concerning past production was published from the court proceedings:

From 1901 to October 28, 1916, the ore mined was 1,650,087 tons, of which 165,984 tons were crude shipping ore having an average content of 59.93 ounces of silver and 54.16 per cent of lead. From 1906 to 1916 there were 1,484,103 tons milled, averaging 8.60 ounces of silver per ton and 9.85 per cent of lead. Concentrates from this mill product totaled 258,604 tons and averaged 44.49 ounces of silver per ton and 52.33 per cent of lead. Receipts for the period were $20,972,610; profits, $11,915,878; and dividends, $9,981,227. The table by years is given by Weed.[1] For 16 years, not including the year 1917 and part of 1916, the mine produced about 21,454,000 ounces of silver and 450,000,000 pounds of lead. In the early part of 1918 the opening of the ore body below the No. 5 level at a depth of 2,000 feet was most encouraging.

The Hecla Mining Co. continued to make shipments of lead ore and concentrate. There was also a good output of zinc concentrate marketed during the year. A large part of the production went to the new plant of the Bunker Hill Co., at Sweeney, Idaho. The mill at Gem, which is equipped with jigs, tables, and flotation cells, was increased to a capacity of 750 tons daily. According to the statement to the county assessor, there were 374,213 tons of ore extracted, which had a gross value of $4,462,030. The cost of extraction was $1,506,639; freight and treatment, $798,165; betterment and repairs, $262,161; and net profit, $1,895,065, from which dividends of $1,600,000 were paid in 1917. Dividends paid to date amount to $6,905,000. Considerable information regarding this mine, including the report for 1917, was recently published.[1] Extracts follow:

---

[1] Weed, H. W., The mines handbook, vol. 13, p. 775, 1918.

> During the year 12,386 feet of development was accomplished—3,473 feet on the Ore-Or-No-Go vein and 8,913 feet on Hecla vein. Main shaft was sunk 210 feet and a new level is to be opened at the 2,000-foot, a point which it is believed the workings have nearly reached. A raise from the 900-foot level, in ore, to the No. 3 adit level, is in progress, and should be completed in June. Ore reserves are estimated at 1,326,399 tons, including 70,000 tons above water level on the Ore-Or-No-Go vein—sufficient supply for four years and one month at the production rate maintained last year. * * * From both veins 374,213 tons were raised, of which 292,726 tons were milled in Gem and Black Cloud mills, 14,474 tons shipped crude, and 67,013 tons classified as waste. Combined mining costs reached $3.493 and milling costs $0.686. Per ton gross receipts were $9.811 and gross expenses $4.029, leaving net per ton profit of $5.782. Total production was 1,366,960 ounces silver, 44,363,559 pounds lead, and 507,888 pounds zinc.
>
> Production for 14 years was 335,053 tons of crude ore and concentrate shipped, containing 9,625,014 ounces of silver and 325,786,612 pounds of lead.

From the Greenhill Cleveland property, controlled by the Federal Mining & Smelting Co., shipments of lead ore, lead concentrate, and lead-zinc concentrate were made at the rate of more than 1,500 tons per month. The ore on this property, however, is said to be practically exhausted at the beginning of 1918. According to the statement to the assessor the mine produced 18,012 tons of crude ore and concentrate, valued at $1,341,331. The cost of extraction was $654,856; freight and treatment, $290,311; betterment and repairs, $258,841; and net profit, $137,323. A 500-ton concentration mill near Wallace, which is equipped for gravity concentration and flotation, was used to treat this ore.

Good shipments of crude lead ore and zinc ore were made from the Frisco property without treatment, as the mill formerly used on the ore of the Frisco mine was sold to the Tamarack & Custer Consolidated Mining Co. at the end of 1916. The statement to the assessor gives 1,260 tons of ore extracted, valued at $62,480. Cost of extraction was $36,107; freight and treatment, $19,650; and net profit, $6,723.

The Marsh property, at Burke, produced milling ore, which was treated at the company's Black Cloud mill north of Wallace. Shipments of lead concentrate and lead-zinc concentrate were made until the property was closed the latter part of the year. The mill was leased to the Hecla Mining Co., and Hecla ore was treated there as well as at the mill at Gem.

There were also shipments made by lessees from the Mace & Burke mine of the Federal Mining & Smelting Co., and several shipments of concentrate from the treatment of creek tailings.

Placer Center district.—Seven deep mines in 1917 produced 159,696 tons of ore, containing $1,757 in gold, 540,748 ounces of silver, 50,159 pounds of copper, 16,450,681 pounds of lead, and 14,363,730 pounds of recoverable zinc, valued in all at $3,340,886, or $20.92 per ton. The ore was divided into 5,629 tons of crude ore shipped to smelters, 151,119 tons of ore concentrated, with 2,948 tons of old tailings re-treated, resulting in 35,257 tons of concentrates. In 1916 the output of ore was 130,076 tons valued at $2,547,727. The Tamarack & Custer Consolidated Mining Co. operated a 500-ton concentration mill equipped with flotation machines and shipped crude lead ore and concentrate to the Northport smelter. There was a slight increase in the output, though the mill was not operated until the middle of the year. According to the statement to the assessor, there were 16,916 tons of crude ore and concentrate marketed having a gross value of $1,338,322. The cost of extraction was $518,799; freight and treatment, $441,020; betterment and repairs, $27,645; and net profit, $350,858. Dividends were paid amounting to $124,340.

---

[1] Norman, S., Northwest mines handbook, vol. 1, p. 78, 1918.

At the Success mine a 250-ton concentration and flotation mill was operated most of the year, and shipments of zinc concentrate were made at the rate of more than 1,000 tons a month. There was also some silver-lead concentrate separated. The property was operated at a loss of $102,091, due, it is said, to an unfavorable smelting contract. According to the statement to the assessor, the ore extracted was 57,297 tons. The amount received from sales of ore was $350,105; the cost of extraction was $335,553; and freight and treatment, $116,643. As expenses were high in 1917 and the management gave no detailed information to stockholders, there was much dissatisfaction, which led to a lawsuit and a change of management.

Shipments of a good grade of zinc concentrate were also made from tailings on Ninemile Creek, near Sunset.

St. Joe district.—The Richmond property became an important shipper of oxidized copper ore, containing about 20 per cent of iron and 30 per cent of silica. The production was nearly a million pounds of copper with some gold. During the year a tramway 8,800 feet long was completed and a compressor installed. The greatest depth attained was 370 feet through a crosscut tunnel 600 feet long, at which point the ore was said to be changed to a sulphide. Dividends were published as $83,200. According to a short printed statement, 7,766 tons, assaying 6.17 per cent copper and 0.156 ounce of gold, were shipped during the year. Receipts were $292,117, and net profit, $97,235.

Summit district.—From the operations of 1 small placer and 4 deep mines, the district had an output of 792 tons of ore, $143 in gold, 2,378 ounces of silver, 275 pounds of copper, 346,548 pounds of lead, and 172,679 pounds of recoverable zinc, valued in all at $49,595. The ore had a value per ton of $62.49. In 1916 the district produced 5,309 tons of ore and had an output valued at $70,285. Shipments of lead ore were made by the Fidelity Co. and by the Henrietta Exploration Co., operating the Bear Top mine. The Murray Hill Mining Co. milled a few hundred tons of ore, which resulted in a zinc concentrate. The best product of the district was high-grade sulphide lead ore and sulphide zinc ore from the Terrible Edith mine. The lead ore is steel galena, and some of it in carload lots assayed 63 per cent of lead.

Yreka district.—Eighteen deep mines produced 807,450 tons of ore, containing $19,484 in gold, 3,303,244 ounces of silver, 926,938 pounds of copper, 124,684,064 pounds of lead, and 7,709,933 pounds of recoverable zinc, valued in all at $14,503,653, or $17.96 per ton. Most of the ore, or 770,376 tons, with 12,783 tons of old tailings, was concentrated, making 137,873 tons of concentrates. In 1916 this district produced 857,066 tons of ore, valued at $11,169,005. The Bunker Hill & Sullivan property was the largest lead producer of the State, though in silver output it was exceeded by that from the Hercules mine, at Burke. Two concentration mills were in operation the entire year, which treated an average of 1,650 tons a day. According to the statement to the county assessor, the company extracted 493.030 tons of ore, valued at $9,584,963. The cost of extraction was $1,473,480; freight and treatment, $4,641,181; betterment and repairs, $1,056,619; and net profit of $2,447,285, which included royalties amounting to $33,602. Dividends for 1917 amounted to $2,043,750, and dividends to date are $20,533,500. Extracts from the annual report[1] follow:

> The mine yielded in 1917 a larger tonnage of ore than during any former year. Besides, we recovered and sold a substantially larger amount of lead and silver than during any year in the history of the property, although our operations were more or less hampered by scarceness of labor and materials and by the same difficulties which have hampered most of the industries of the country. Not only was this record production made, but the sinking of our main shaft to the No. 15 level was completed, the No. 15 shaft and pump stations were excavated, and the No. 15 crosscut was well advanced. The above-mentioned operating difficulties have resulted in higher costs per ton than the average of former years, but because of increased output, as well as the introduction of improved ore-handling methods in our newer work, the costs per ton did not exceed those of 1916. * * *
>
> The development during the year on Bunker Hill No. 14 level has been most satisfactory. Although we have not yet cut the ore on the No. 15 level, it is believed that the lateral extensions made to the known ore on No. 14, and other levels, will make available an ore tonnage in excess of the quantity extracted during the year. It is confidently expected that within a few weeks the No. 15 crosscut will penetrate the ore, when a very substantial addition will be made to our ore reserves.
>
> We have 3,457,419 tons of ore blocked out to date. * * *
>
> The mine was in operation for the full period of 12 months and produced 492,617 tons of concentrating ore and 413 tons from exploration at a cost of $1,176,074.56; * * * 1.524 feet of drifts, raises, crosscuts, and shaft work were driven at a cost of $30,579.80. * * *
>
> The concentrators were in operation for the full year. * * *
>
> During the year 493,030 tons of ore were concentrated, making the average work of the concentrators 1.351 tons per day, or say 1,385 tons per 24 hours of actual operation, at a cost of $295,964.61. * * *
>
> The company shipped 102,911.51 tons concentrates, at a cost of $23,402.

The ore milled—493,030 tons—assayed 10.65 per cent lead and 4.32 ounces of silver. From this ore, 103,982 tons of concentrates were produced, containing 93,992,898 pounds of lead and 1,692,765 ounces of silver. The loss in tailing was 10.49 per cent of the lead and 20.40 per cent of the silver in ore milled, or a total of 11.88 per cent. The total cost per pound of lead was 6.64 cents, a considerable increase. From 1886 to 1917 the company has mined 7,886,886 tons of ore having a gross value of $80,247,373. Net smelter returns were $46,975,409, and operating profit $26,261,032.

The Bunker Hill smelter and refinery were completed in 1917, and three furnaces, having a combined capacity of 1,000 tons per day were in operation by the end of the year. The products from custom ore treated were desilverized lead, fine silver, and gold. The Bunker Hill & Sullivan Mining & Concentrating Co. had a contract with the American Smelting & Refining Co. to treat the output of the mine. When the Bunker Hill smelter was put in operation the American Smelting & Refining Co. protested against a diversion of the ores and applied for an injunction against the Bunker Hill Co. Later the matter was settled out of court, and a new contract was signed, by which half the mine product is to be treated at Kellogg and half at the various plants of the American Smelting & Refining Co.

---

[1] Bunker Hill & Sullivan Mining & Concentrating Co. Thirtieth Ann. Rept., for year ending Dec. 31, 1917.

The Caledonia Mining Co. continued to ship ore and concentrate at the rate of about 1,500 tons per month. This ore is rather low in lead compared with other properties, but it contains considerable silver. According to the statement to the assessor, there were 38,577 tons extracted having a gross value of $1,849,255. The cost of extraction was $137,111; freight and treatment, $484,989; and net profit, $1,227,155. Dividends of $937,800 were paid for the year, and $2,901,606 to date. According to the printed report[1] of the company, the output of the Caledonia in 1917 was 27,122 tons milled and 17,983 dry tons crude ore and concentrate shipped. These shipments produced 1,068,700 ounces of silver, 544,802 pounds of copper, and 9,434,900 pounds of lead. The totals are slightly less than those of 1916.

> During the year many hundred feet of development work was done, trying to find new ore, or the downward extension of the old ore bodies. In this we were unsuccessful. The amount of war tax we will have to pay is unknown, but it will be a large sum. We intend to continue the present dividend rate as long as it is policy to do so.

The Last Chance mine, of the Federal Mining & Smelting Co., was practically exhausted in the upper levels, and the property was turned over to the Bunker Hill Co. according to previous arrangements. During the year considerable lead concentrate and crude lead ore were marketed. According to the statement to the assessor, this property at Wardner produced 147,347 tons of ore, having a gross value of $626,686. The cost of extraction was $401,344; freight and treatment, $170,458; and net profit, $54,884. Notes of the operating company are given under Hunter district.

The Stewart Mining Co., operating the Stewart mine and the Crown Point mine of the Coeur d'Alene Development Co., produced about 2,000 tons of milling ore per month, which resulted in lead concentrate. A 200-ton plant using Hardinge mill, jigs, Wilfley tables, and flotation, was active.

The Hypotheek property produced nearly 40,000 tons of ore, which was considerably oxidized and principally of milling grade. A 200-ton concentration mill was operated and the product shipped to the United States smelter at Salt Lake City, Utah. There were several other properties shipping crude lead ore or concentrate, including the Ontario, Sierra Nevada, and Hays Co., working on tailings, and the Alhambra property, using a 35-ton flotation mill. The Big Creek Mining Co. made shipments of sulphide copper ore containing considerable silver. Low-grade copper ore was concentrated at the

---

[1] Caledonia Mining Co. Ann. Statement for year ending Dec. 31, 1917.

Horst-Powell property, north of Kellogg. The mine, however, was closed in the latter part of 1917.

One of the largest zinc producers in the district was the Highland Surprise Co., which operated a mill and shipped zinc concentrate to various smelters in the East, but especially to the Anaconda zinc plant at Great Falls, Mont. The Anaconda Copper Co. leased and operated the Douglas mine, and lead-zinc ore was shipped for leaching. The mine was operated continuously in 1917, though shipments were irregular owing to impassable wagon roads. According to the statement to the assessor, there were 7,799 tons extracted, having a gross value of $346,718. Cost of extraction was $179,286; freight and treatment, $143,595, and net profit, $23,477. Dividends of $17,050 were paid by the Douglas Co. from royalty.

The Constitution mine was also a considerable shipper of sulphide lead-zinc ore and concentrate, which contained more than a million pounds of recoverable zinc. A 100-ton concentration and flotation plant was in active operation. The Black Hawk mine, belonging to the Federal Mining & Smelting Co., was operated through lessees. A large production of lead concentrate and lead-zinc concentrate was marketed. According to the figures to the assessor, there were 15,600 tons of ore extracted, having a gross value of $117,126. The cost of extraction was $66,948; freight and treatment, $46,305; and net profit, $3,873.

The Nabob property produced some lead-zinc shipping ore and lead concentrate of a good grade, and a few tons of lead concentrate came from the Wyoming property.

TWIN FALLS COUNTY.

Three small placers produced $251 in gold and 1 ounce of silver from along Snake River.

VALLEY COUNTY.

From the southern part of Idaho County and the northern extension of Boise County, a new county was formed during 1917 known as Valley County. The production of six small mines had a total value of $1,436 in gold and silver. In the Big Creek district the Snowshoe mine produced some ore which was treated in a 1-stamp mill using amalgamation. In the Payette River district, near Emmett, the Three Sisters property made a test shipment of siliceous silver ore.

WASHINGTON COUNTY.

One shipment of lead ore was made from the Galena Silver mine, near Council, Idaho, in the Heath district.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN WASHINGTON.

(MINES REPORT.)

By C. N. GERRY.

PRODUCTION.

GENERAL STATEMENT.

The value of the mine production of gold, silver, copper, lead, and zinc in Washington in 1917 was $2,289,285, an increase of 12 per cent over that of 1916. There was a moderate increase in the quantity of ore mined, and a decided increase in the production of lead, but the output of gold, silver, copper, and zinc were less in quantity than in 1916. The output of lead and the total value of the metals were records for the State, being greater than any previous yearly figures. Dividends paid by four companies in 1917 amounted to $344,823. During 57 years the State has produced gold, silver, copper, lead, and zinc valued at $36,486,666, of which more than 75 per cent was for gold.

Mine production of gold, silver, copper, lead, and zinc in Washington in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	113	164,998	$577,655	335,121	2,645,022	5,399,274	1,693,734	$2,048,350
1917	136	172,119	492,324	282,320	2,199,518	9,789,687	1,195,567	2,289,285
Increase or decrease, 1917		+7,121	−85,331	−52,801	−445,504	+4,390,413	−498,167	+240,935
Total, 1860–1917			27,448,692	7,053,440	10,922,800	27,257,104	3,154,797	36,486,666

ORE.

The quantity of ore sold or treated increased from 164,998 tons in 1916 to 172,119 tons in 1917, or more than 4 per cent. There was an increase of 13,228 tons in Stevens County, but a decrease of 5,787 tons in Ferry County. The total value per ton of the ore increased from $12.36 in 1916 to $13.27 in 1917, but the value per ton in gold and silver decreased from $4.79 to $4.18. Of the total output of ore, more than 38 per cent was dry or siliceous ore, more than 43 per cent copper ore, 9 per cent lead ore, and nearly 9 per cent lead-zinc ore. The siliceous ore averaged per ton $8.83 in gold and silver;

the copper ore, $1.78; the lead ore, 28 cents; and the lead-zinc ore, 8 cents. The siliceous ore was composed of 65,058 tons of gold ore, averaging per ton $7.36 in gold, 1.54 ounces of silver, and 0.76 pound of copper; 533 tons of silver ore, averaging per ton $1.67 in gold, 36.11 ounces of silver, 4.16 pounds of copper, and 2.36 pounds of lead; and 48 tons of gold and silver ore, averaging per ton $13.29 in gold, 23 ounces of silver, and 51.14 pounds of lead. The gold ore includes 4,966 tons of sulphide iron ore, containing 102.33 ounces of gold, 467 ounces of silver, and 19,837 pounds of copper. This class of ore amounted to 10,956 tons in 1916. The siliceous ore, with the iron ore, averaged per ton $7.31 in gold, 1.84 ounces of silver, with a trace of copper and lead. Copper ore as mined averaged 8 cents in gold and 2.06 ounces of silver per ton and 1.43 per cent of copper, or a total value of $9.59. Lead ore averaged 0.34 ounce of silver per ton and 29.68 per cent of lead, or a total value of $51.34. Zinc ore, all of which was of shipping grade, contained 18.93 per cent of recoverable zinc, or a value of $38.61 per ton, and lead-zinc ore, which was all milled, averaged 0.15 per cent lead and 3.85 per cent recoverable zinc, and had a total value per ton of $8.22. Nearly all of the lead ore and most of the siliceous ore was shipped without treatment, but all of the lead-zinc ore and most of the copper ore was concentrated.

Ore and metals produced in Washington in 1917.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	17	....	283.86	86	....	....	....
Dry or siliceous ore	56	65,639	23,240.61	120,510	51,391	4,483	....
Copper ore	43	75,006	281.93	154,747	2,147,102	....	....
Lead ore	18	16,407	1.55	5,630	535	9,739,302	....
Zinc ore	2	114	....	....	....	....	43,149
Lead-zinc ore	2	14,953	8.22	1,347	490	45,902	1,152,418
	....	172,119	23,816.17	282,320	2,199,518	9,789,687	1,195,567

Ore sold or treated from Washington in 1917, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Lead-zinc ore.	Total.
Chelan	21	....	....	....	....	21
Ferry	53,197	5,933	1	....	....	59,131
King	180	....	....	....	....	180
Kittitas	12	37	....	....	....	49
Okanogan	658	1,167	....	....	....	1,825
Pend Oreille	....	....	107	36	14,953	15,096
Pierce	....	18	....	....	....	18
Skagit	14	....	....	....	....	14
Snohomish	1	2,837	....	....	....	2,838
Stevens	657	65,009	16,299	78	....	82,043
Whatcom	10,897	....	....	....	....	10,897
Yakima	2	5	....	....	....	7
	[a] 65,639	75,006	16,407	114	14,953	172,119
Average value per ton in gold and silver	$8.83	$1.78	$0.28	....	$0.08	$4.18

[a] Includes 65,058 tons of gold ore, 48 tons of gold and silver ore, and 533 tons of silver ore.

Six milling plants were active in 1917, of which 3 used amalgamation, 2 used concentration. and 1 was equipped for amalgamation and concentration. The United Copper mill at Chewelah continued the use of flotation with table concentration, and a considerable quantity of ore was amalgamated at the Boundary Red Mountain property, in Whatcom County. The cyanide mill at Republic was idle, as all of the ore was shipped directly to smelters.

Gold and silver mills treated more than 6 per cent of the total quantity of ore and tailings, or 10,986 tons, in 1917, against 12,702 tons in 1916.

Most of the ore treated came from Whatcom County, near Sumas. No cyanide was consumed, but 185 pounds of mercury was used in 4 milling plants. The average consumption of mercury was 0.0168 pound per ton of ore amalgamated and 0.026 pound per ounce of gold and silver bullion saved.

Gold and silver produced at mills in Washington in 1917.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Chelan	17	11.84	2			$246
Ferry	10			12.84	50	307
Kittitas	12	9.19	3			192
Okanogan	[a] 90	72.72	34			1,531
Whatcom	10,855	6,625.63	372			137,271
Yakima	2	1.56				31
	10,986	6,720.88	411	12.84	50	139,578

[a] Also yielded 2 tons of concentrates.

Nearly 43 per cent of the output of ore, or 73,673 tons, was concentrated, an increase from 53,635 tons in 1916. Concentrates increased from 4,130 tons to 6,076 tons. The greater part was a copper concentrate from the Chewelah district, in Stevens County, and most of the remainder was zinc concentrates together with a small quantity of lead concentrates from the Metaline district, in Pend Oreille County. Copper concentrates averaged 21 cents in gold and 26.96 ounces of silver per ton and 10.33 per cent of copper and had an average value per ton of $78.02. Lead concentrates averaged $3.54 in gold and 28.06 ounces of silver per ton and 47.81 per cent of lead and had a value per ton of $111.70. Zinc concentrates averaged 42.43 per cent of recoverable zinc and had a value per ton of $86.56.

Mine production of metals from Washington concentrates in 1917.[a]

County.	Ore to concentrating mills.	Concentrates.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value of concentrates.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Okanogan		2	6.22	15				$141
Pend Oreille	14,953	1,406	8.22	1,347	490	45,902	1,152,418	122,908
Stevens	58,720	4,668	46.98	121,194	964,750			364,213
	73,673	6,076	61.42	122,556	965,240	45,902	1,152,418	487,262

[a] The concentrates from Chelan County were gold concentrates in 1917, those from Stevens County were all classified as copper concentrates, and those from Pend Oreille were mostly zinc, except two shipments of lead concentrates.

Nearly 51 per cent of the ore, or 87,416 tons, was mined and shipped directly to smelters. The greatest quantity of ore come from Ferry County, but a more valuable product came from Stevens County. Of the first-class or shipping ore, more than 62 per cent was siliceous, more than 18 per cent copper ore, nearly 19 per cent lead ore, and less than 1 per cent zinc ore. The siliceous ore shipped to smelters averaged per ton $6.23 in gold, 2.20 ounces of silver, and 0.94 pound of copper, and was valued at $8.30. Copper ore shipped averaged 30 cents in gold and 2.06 ounces of silver per ton and 3.63 per cent of copper and was valued at $21.82 per ton. First-class lead ore shipped had an average assay of 0.34 ounce of silver per ton and 29.68 per cent of lead and was valued at $51.34 per ton. Crude zinc ore shipped averaged 18.93 per cent of recoverable zinc and had a value of $38.61 per ton. Most of the copper ore shipped, or 16,143 tons, was sulphide, containing 233.83 ounces of gold, 33,429 ounces of silver, and 1,163,581 pounds of copper. The sulphide lead ore shipped was 2,575 tons, containing 0.58 ounce of gold, 4,150 ounces of silver, 535 pounds of copper, and 2,968,168 pounds of lead. Of the zinc ore shipped, 78 tons was sulphide, containing 18;852 pounds of recoverable zinc. The oxidized copper ore—143 tons—averaged 6.56 per cent of copper, and the oxidized or carbonate lead ore—13,832 tons—averaged 24.48 per cent of lead.

Mine production of metals from Washington crude ore shipped to smelters in 1917.

By counties.

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Chelan	4	16.94	8				$356
Ferry	59,121	16,051.09	98,030	273,624	1,395		487,401
King	180	277.77	2,706	4,870			9,301
Kittitas	37		15	4,002			1,104
Okanogan	1,735	214.90	14,566	83,524	2,455		39,457
Pend Oreille	143		205		84,422	24,297	9,908
Pierce	18		47	3,084			881
Skagit	14	.58	508				431
Snohomish	2,838	20.76	1,151	180,948			50,777
Stevens	23,279	101.76	39,776	682,740	9,654,746	18,852	1,053,498
Whatcom	42	20.42	2,128				2,171
Yakima	5	.15	34	1,486			437
	87,416	16,704.17	159,174	1,234,278	9,743,018	43,149	1,655,720

By kinds of ore.

Dry or siliceous	54,609	16,467.67	119,991	51,391	3,716		$453,636
Copper	16,286	234.92	33,553	1,182,352			355,286
Lead	16,407	1.58	5,630	535	9,739,302		842,397
Zinc	114					43,149	4,401

GOLD.

The mine production of gold was valued at $492,324, against $577,655 in 1916, a decrease of nearly 15 per cent. Of this total more than 70 per cent came from ores shipped directly to smelters, 28 per cent came from ores treated by amalgamation or cyanidation, more than 1 per cent was from placers, and less than 1 per cent was from concentrates. The table below shows that siliceous ore supplied most of the gold, or nearly 98 per cent, and that copper ore contained 1 per cent of the total. There was decided decrease in gold recovered from siliceous ores.

Mine production of gold in Washington in 1917, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Lead-zinc ore.	Total.
Chelan	4.26	28.78				33.04
Clallam	30.19					30.19
Ferry		15,930.46	133.47			16,063.93
King		277.77				277.77
Kittitas	225.33	9.19				234.52
Okanogan	15.91	264.94	28.90			309.75
Pend Oreille					8.22	8.22
Skagit		.58				.58
Snohomish	4.30	1.20	19.56			25.06
Stevens		80.34	99.85	1.55		181.74
Wahkiakum	3.87					3.87
Whatcom		6,645.85				6,645.85
Yakima		1.50	.15			1.65
	283.86	[a] 23,240.61	281.93	1.55	8.22	23,816.17

[a] Includes 23,166.31 ounces from gold ore, 30.89 ounces from gold and silver ore, and 43.41 ounces from silver ore.

SILVER.

The mine production of silver decreased from 335,121 ounces, valued at $220,510, in 1916 to 282,320 ounces, valued at $232,632, in 1917, a decrease of nearly 16 per cent in quantity but an increase in value. Stevens and Ferry counties had the largest production. Crude ore shipped to smelters supplied more than 56 per cent of the total, concentrates more than 43 per cent, and placers and mill bullion less than 1 per cent. Siliceous ore contained nearly 43 per cent, copper ore nearly 55 per cent, and lead ore 2 per cent. Silver usually accompanies the lead ore in the Western States, but there is practically no silver in the ore of the Electric Point mine near Northport.

Mine production of silver in Washington in 1917, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Lead-zinc ore.	Total.
Chelan		10				10
Clallam	5					5
Ferry		96,854	1,204	22		98,080
King		2,706				2,706
Kittitas	79	3	15			97
Okanogan	2	12,884	1,731			14,617
Pend Oreille				205	1,347	1,552
Pierce			47			47
Skagit		508				508
Snohomish			1,151			1,151
Stevens		5,045	150,565	5,403		161,013
Whatcom		2,500				2,500
Yakima			34			34
	86	[a] 120,510	154,747	5,630	1,347	282,320

[a] Includes 100,158 ounces from gold ore, 1,104 ounces from gold and silver ore, and 19,248 ounces from silver ore.

COPPER.

The mine production of copper decreased from 2,645,022 pounds, valued at $650,675, in 1916 to 2,199,518 pounds, valued at $600,468, in 1917. The production increased slightly in Stevens and Okanogan counties, but decreased considerably in Ferry County. Crude ore produced more than 56 per cent of the copper and concentrates nearly 44 per cent. Most of the metal came from copper ore and only a little more than 2 per cent from siliceous ore.

Mine production of copper in Washington in 1917, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Lead-zinc ore.	Total.
Ferry	41,935	231,689	....	....	273,624
King	4,870	....	....	....	4,870
Kittitas	....	4,002	....	....	4,002
Okanogan	2,527	80,997	....	....	83,524
Pend Oreille	....	....	....	490	490
Pierce	....	3,084	....	....	3,084
Snohomish	....	180,948	....	....	180,948
Stevens	2,059	1,644,896	535	....	1,647,490
Yakima	....	1,486	....	....	1,486
	[a] 51,391	2,147,102	535	490	2,199,518

[a] Includes 49,172 pounds from gold ore and 2,219 pounds from silver ore.

LEAD.

There was a record mine production of lead in the State in 1917, as well as in 1916; the output increased from 5,399,274 pounds, valued at $372,550, in 1916 to 9,789,687 pounds, valued at $841,913, in 1917. This total represents an increase of more than 81 per cent in the production, which came principally from the mines of the Northport district of Stevens County, where encouraging development of galena and carbonate ore continues. Less than 1 per cent of the lead came from concentrates. Of the lead ore shipped, 13,832 tons were carbonate containing 6,771,134 pounds of lead and 2,575 tons were sulphide containing 2,968,168 pounds of lead.

ZINC.

The mine production of recoverable zinc was 1,195,567 pounds, valued at $121,948, against 1,693,734 pounds, valued at $226,960, in 1916. Zinc and lead-zinc ores were mined in the Metaline and Bossburg districts. Crude ore supplied 43,149 pounds and concentrates 1,152,418 pounds. The closing of the Great Western and Last Chance mines in the Northport district reduced the State output of zinc.

MINING INDUSTRY.

Mining conditions in Washington during 1917 were in many respects similar to those of other Western States. Metal prices for silver, copper, and lead were higher during the first part of the year, and fluctuated until the Government fixed the price of copper and zinc. The cost of labor and supplies was abnormally high, and men were scarce, owing to the draft for the Army. Smelting conditions in Washington and British Columbia were also unfavorable to greater production. The smelter at Trail, British Columbia, which receives siliceous ore, copper ore, and lead ore from Washington, suffered from shortage of coke and from labor strikes, so that mines in the eastern part of the State were forced to ship ore to the Tacoma smelter in the western section, where they had no smelting contract. A strike at Republic interfered with production, and the ore shipped was of lower grade. Notwithstanding these adverse conditions, the lead output of the State was considerably increased. The output of zinc, however, fell short of the former production, owing partly to depletion of ore bodies. The increased value of silver and copper and a record output of lead overbalanced the decrease in the quantity of gold, silver, copper, and zinc, so that the total value of the five metals was greater than that in any previous year. More dividends were paid in 1917, though the total is not large compared with other States.

Mine production of gold, silver, copper, lead, and zinc in Washington in 1917.

County.	Ore.	Gold.		Silver.	
		Quantity.	Value.	Quantity.	Value.
	Short tons.	*Fine oz.*		*Fine oz.*	
Chelan	21	33.04	$683	10	$8
Clallam		30.19	624	5	4
Ferry	59,131	16,063.93	332,071	98,080	80,818
King	180	277.77	5,742	2,706	2,230
Kittitas	49	234.52	4,848	97	80
Okanogan	1,825	309.75	6,403	14,617	12,044
Pend Oreille	15,096	8.22	170	1,552	1,279
Pierce	18			47	39
Skagit	14	.58	12	508	419
Snohomish	2,838	25.06	518	1,151	948
Stevens	82,043	181.74	3,757	161,013	132,675
Wahkiakum		3.87	80		
Whatcom	10,897	6,645.85	137,382	2,500	2,060
Yakima	7	1.65	34	34	28
	172,119	23,816.17	492,324	282,320	232,632

County.	Copper.		Lead.		Recoverable zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Chelan							$691
Clallam							628
Ferry	273,624	$74,699	1,395	$120			487,708
King	4,870	1,329					9,301
Kittitas	4,002	1,092					6,020
Okanogan	83,524	22,802	2,455	211			41,460
Pend Oreille	490	134	130,324	11,208	1,176,715	$120,025	132,816
Pierce	3,084	842					881
Skagit							431
Snohomish	180,948	49,399					50,865
Stevens	1,647,490	449,765	9,655,513	830,374	18,852	1,923	1,418,494
Wahkiakum							80
Whatcom							139,442
Yakima	1,486	406					468
	2,199,518	600,468	9,789,687	841,913	1,195,567	121,948	2,289,285

Ore sold or treated, deep mines producing, and average value of ores in Washington, in 1916 and 1917.

County.	Ore sold or treated, 1917.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	Quantity.	Increase or decrease.	1916	1917	1916	1917	1916	1917
	Short tons.	*Short tons.*						
Asotin	....	− 1	1	....	$55.00	....	$28.00	....
Chelan	21	− 1,288	5	4	6.55	$28.71	6.55	$28.71
Ferry	59,131	− 5,787	23	20	10.69	8.25	7.55	6.98
King	180	+ 131	1	1	35.02	51.67	35.02	44.29
Kittitas	49	+ 44	2	6	22.40	26.47	22.40	4.18
Okanogan	1,825	− 141	18	25	19.43	22.54	15.48	9.93
Pend Oreille	15,096	− 49	1	7	7.80	8.80	....	.09
Pierce	18	− 116	1	1	20.22	48.94	1.16	2.17
Skagit	14	+ 14	....	2	....	30.78	....	30.78
Skamania	....	− 8	1	....	49.25	....	9.88	....
Snohomish	2,838	+ 740	4	7	35.33	17.89	.69	.48
Stevens	82,043	+13,228	30	39	14.08	17.29	1.80	1.66
Whatcom	10,897	+ 347	3	5	12.65	12.80	12.65	12.80
Yakima	7	+ 7	....	2	....	66.86	....	8.86
	172,119	+ 7,121	90	119	12.36	13.27	4.79	4.18

[a] Placer product excluded.

There were 17 active placer mines, of which 15 were worked by hydraulic and sluicing methods and 2 by drifting. Of the 119 deep mines, 8 produced gold; 35, gold and silver; 5, copper; 46, gold, silver, and copper; 2, silver; 3, gold, silver, and lead; 1, zinc; 15, silver and lead; 2, gold, silver, copper, and lead; 1, silver, lead, and zinc; and 1 gold, silver, copper, lead, and zinc.

REVIEW BY COUNTIES.

CHELAN COUNTY.

From 4 deep mines and 1 placer the county output was 21 tons of ore, $683 in gold, and 10 ounces of silver. This represents a decrease of $7,999 in gold and 167 ounces of silver. Information concerning the mining companies operating in this and other counties of the State is given in a recently published reference book,[1] which also gives short articles on the important mining districts.

Blewett district.—A small output of gold bullion came from the Ivanhoe property, principally from development work.

Entiat district.—A small shipment of siliceous gold ore was made, but the Rex mine, formerly a good producer, was idle.

CLALLAM COUNTY.

Placer gold valued at $624, with 5 ounces of silver, was produced near Ozette, Clallam County.

---

[1] Norman, Sidney, Northwest mines handbook, 1918.

FERRY COUNTY.

Mine production in Ferry County, Wash., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	
1916	25	64,918	$399,376	138,293	828,264	3,646	$694,378
1917	20	59,131	332,071	98,080	273,624	1,395	487,708
Decrease, 1917	....	5,787	67,305	40,213	554,640	2,251	206,670

There was a decided decrease in the quantity of ore mined and metals produced in Ferry County in 1917. Twenty deep-mine operators produced 59,131 tons of ore, a decrease of nearly 9 per cent from 1916. The value of the ore also decreased considerably, from $10.69 to $8.25 per ton. Only 10 tons was treated in gold and silver mills, and the remainder, 59,121 tons, having a value of $487,402, or $8.24 per ton, was shipped directly to smelters. Of the total output, 53,197 tons were siliceous ore, 5,933 tons were copper ore, and 1 ton was lead ore. Ferry County produced more than 67 per cent of the gold of the State, nearly 35 per cent of the silver, and 12 per cent of the copper.

Belcher district.—The Belcher mine was operated for a short time in 1917 and shipments of sulphide iron ore were made to Canadian smelters. The Laurier Mining Co. made a few shipments of sulphide copper ore. Formerly the output of both these properties was greater.

Curlew district.—Some old dump material, containing gold and silver, was shipped from the California property, and the Boston & New York group produced a small shipment of siliceous silver ore and one of copper ore.

Danville district.—Three deep mines produced 7,337 tons of ore, containing $22,263 in gold, 2,174 ounces of silver, and 242,942 pounds of copper, valued in all at $90,377, or an average value per ton of $12.32. In 1916 the district produced 18,436 tons of ore, valued at $198,199. All the ore was shipped without treatment and consisted of a copper sulphide ore from the Lone Star & Washington property and a siliceous gold ore from the Lucile Dreyfus mine, operated by the Virginia Mining Co.

Republic district.—Eleven deep mines produced 46,785 tons of ore, containing gold valued at $305,331 and 94,718 ounces of silver. The value of this ore was $383,379, or $8.19 per ton. Fourteen deep mines in 1916 produced 45,313 tons of ore, valued at $467,791. There was, therefore, a slight increase in the ore output, but a decided decrease in the value of the product. As this ore is used at the smelters primarily for its silica, some of it is shipped regardless of its low content of gold. With the exception of 10 tons milled, the entire output was shipped to various smelting plants. From 1896 to the end of 1917 the Republic district produced 469,043 tons of ore, yielding $6,421,686 in gold and 1,875,744 ounces of silver, valued together at $7,483,666. The largest producer of the district was, as formerly, the Lone Pine-Surprise-Pearl property, operated by the Northport

Smelting & Refining Co. In fact, more than half of the district output came from this property. The ore of the Knob Hill mine is of a much better grade, and though only about 6,000 tons of ore were shipped from the property, the content of gold was the largest production from the district. The company reported receipts of $102,143, from which dividends amounting to $34,784 were paid. The Last Chance mine, developed by a vertical shaft 530 feet deep, was an important producer. The ore was shipped to Tacoma. Development proceeded in a thorough manner at these mines, though work was affected by a shortage of labor. Other shippers were the Black Tail, Tom Thumb, Quilp, and Old Republic mines. The San Poil, formerly a considerable producer, shipped less than 1,000 tons. On November 15, 1917, a strike was called at the Trail smelter, and the plant was idle until late in December. Earlier in the year there were difficulties on account of a shortage of coke. Washington mines, and especially those at Republic, Chewelah, and Northport, are served by the following smelters: Canada Copper Corporation, Greenwood, British Columbia, copper plant, capacity 2,500 tons; Granby Consolidated Mining, Smelting & Power Co., Grand Forks, British Columbia, copper plant, 4,400 tons; Granby Consolidated Mining, Smelting & Power Co., Anyox, British Columbia, copper plant, 2,000 tons; Tacoma Smelting Co., Tacoma, Wash., copper plant, 2,500 tons; Northport Smelting Co., Northport, Wash., lead plant, 1,000 tons; Consolidated Mining & Smelting Co., Trail, British Columbia, lead plant, 350 tons, and copper plant, 1,800 tons; Ladysmith Smelting Corporation (Ltd.), Ladysmith, British Columbia, copper plant, 300 tons.

KING COUNTY.

Several shipments of arsenical pyrite, containing gold, silver, and copper, were made from the Apex mine, near Berlin. The ore also contained some lead, which was lost in a copper smelter.

KITTITAS COUNTY.

Six deep mines and 8 placers produced 49 tons of ore, $4,848 in gold, 97 ounces of silver, and 4,002 pounds of copper, valued in all at $6,020.

Cle Elum district.—The Mineral Creek Copper Co. and the Bononza Copper Co. made shipments of sulphide copper ore.

Swauk district.—Three small deep mines and 8 placers had an output valued at $4,915. The 8 placers produced $4,658 in gold and 79 ounces of silver. The Ford placer and the Golden Rule group were the largest producers.

OKANOGAN COUNTY.

Twenty-five deep mines and 4 placers produced 1,825 tons of ore, $6,403 in gold, 14,617 ounces of silver, 83,524 pounds of copper, and 2,455 pounds of lead, valued in all at $41,460. There was a decrease in the quantity of ore treated and in the production of gold and silver. The total value of the ore increased from $19.43 per ton in 1916 to $22.54 in 1917, but the gold and silver value per ton decreased from

$15.48 to $9.93. Most of the ore, 1,735 tons, was shipped directly to the smelters and contained $4,442 in gold, 14,566 ounces of silver, 83,524 pounds of copper, and 2,455 pounds of lead, valued in all at $39,457, or $22.74 per ton. There were also 90 tons treated in gold and silver mills. The ore was classified as 1,167 tons of copper ore and 658 tons of siliceous ore.

Cascade district.—A shipment of rich silver ore was made from the Phil Sheridan property, operated by the Carey Mining & Milling Co., but only a small clean-up was made from the Bodie mine, formerly a fair producer.

Conconully district.—Production from the Arlington mine was small, only one shipment of siliceous silver ore having been made to Tacoma.

Meyers Creek district.—Eight deep mines and 1 placer produced 406 tons of ore, $2,951 in gold, 549 ounces of silver, and 11,378 pounds of copper, having a total value of $6,509. The production in 1916 was valued at $21,958. Nearly all the ore was shipped to smelting plants. The Eagle and the Reco properties produced a rich gold ore, and the Neutral and the Caribou properties copper ore.

Okanogan district.—There were four small producers in the district, but the Spokane mine, operated by the Morgan Mines Co., was the only one of importance. Two shipments of siliceous gold and silver ore were made during the year.

Palmer Mountain district.—Ten deep mines produced 1,225 tons of ore, containing $1,591 in gold, 5,690 ounces of silver, 69,619 pounds of copper, having a total value of $25,285, or $20.64 per ton. A new and considerable production of copper ore came from the Copper World Extension mine, near Loomis, and a better grade of ore, containing some gold and silver, came from the O. K. Copper property at Oroville. The Pyrargyritic Mining Co. produced several shipments of rich silver ore. Other producers were the 49th Parallel, Golden Chariot, and Pinnacle properties. A custom concentration plant, designed to treat 100 tons per day, was being constructed by the Bender Metals Milling Co. at Nighthawk.

PEND OREILLE COUNTY.

Metaline district.—Six deep mines produced 15,093 tons of ore, containing $170 in gold, 1,504 ounces of silver, 490 pounds of copper, 129,639 pounds of lead, and 1,176,715 pounds of recoverable zinc, valued in all at $132,717, or $8.79 per ton. Nearly all of this ore was milled, only 140 tons being shipped directly to the smelters. Most of the output came from the Josephine mine of the Lead Zinc Co., which operated a 175-ton concentration plant using tables and flotation. The main product was a zinc concentrate shipped to eastern smelters and to the electrolytic plant at Trail, British Columbia. Early in 1918 the company was in financial difficulties and all machinery was sold. Small shipments of lead ore were made from the Belle of May, Lead King, Metaline Consolidated, and Lead Queen mines. A test shipment of lead-zinc ore came from the Metaline Oriole property.

Newport district.—A small shipment of lead ore, containing considerable silver, was shipped from the Eagle mine.

PIERCE COUNTY.

Glacier Basin district.—The Mount Rainier Mining Co. made a shipment of sulphide copper ore.

Copper smelting and refining at the Tacoma plant were uninterrupted throughout the year. Custom ore from Washington mines is treated, but most of the ore comes from Alaska, South America, British Columbia, and the Western States.

SKAGIT COUNTY.

Small shipments of siliceous silver ore came from the Jackman Creek district, near Rockport.

SNOHOMISH COUNTY.

Seven deep mines and 1 placer produced 2,838 tons of ore, $518 in gold, 1,151 ounces of silver, and 180,948 pounds of copper, valued in all at $50,865. This production represents a general decrease. The ore which was shipped directly to smelters, had a value of $17.89 per ton, and was practically all copper ore.

Index district.—Four mines in this district produced almost all of the county output. The main producer was the Sunset property at Index, which was operated the entire year, and shipped sulphide copper ore. A 150-ton concentrator was being installed in the fall of 1917, but is not yet complete. A shipment of high-grade copper ore was made from the Bush & Curry mine.

Sultan district.—Aside from a small placer production, the principal producer was the Florence Rae Copper Co., which made one shipment of sulphide copper ore containing some silver.

STEVENS COUNTY.

Mine production in Stevens County, Wash., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	30	68,815	$8,972	174,612	1,478,357	5,356,229	832,412	$968,666
1917	39	82,043	3,757	161,013	1,647,490	9,655,513	18,852	1,418,494
Increase or decrease, 1917	......	+13,228	−5,215	−13,599	+169,133	+4,299,284	−813,560	+449,828

The output of ore and the quantity of copper and lead produced during the year increased, but the production of gold, silver, and zinc decreased. Thirty-nine deep mines produced 82,043 tons of ore, an increase of 13,228 tons. The value per ton increased from $14.08 in 1916 to $17.29 in 1917, but the gold and silver value decreased from $1.80 to $1.66 per ton. Most of the ore, or 58,720 tons, was milled and yielded 4,668 tons of concentrates valued at $364,213, or $78.02 per ton. The remainder, 23,279 tons, was shipped directly to the smelters and had a total value of $1,053,497, or $45.25 per ton. Of the total output, 65,009 tons were copper ore, 16,299 tons lead ore, 657 tons siliceous ore, and 78 tons zinc ore.

Bossburg district.—The Young America mine, near Bossburg, made a shipment of low-grade zinc ore to the leaching plant at Great Falls, Mont. The Bonanza mine continued to make shipments of lead ore, which was mined by lessees.

Cedar Canyon district.—Four deep mines produced 913 tons of ore, $326 in gold, 5,098 ounces of silver, and 121,372 pounds of copper, valued in all at $37,662, or $41.25 per ton. Shipments of copper ore came from the Turk mine, operated by the High Grade Mining Co., and several shipments of silver ore came from the Silver Queen property.

Chewelah district.—From 1901 to the end of 1917 this district has produced 203,187 tons of ore, yielding $62,330 in gold, 952,679 ounces of silver, 5,816,437 pounds of copper, and 265,139 pounds of lead, having a total value of $1,834,159. Ten deep mines in 1917 produced 62,436 tons of ore, containing $1,508 in gold, 150,137 ounces of silver, and 1,212,608 pounds of copper, valued in all at $456,263, or $7.31 per ton. Of the ore, 58,720 tons were concentrated and 3,716 tons were shipped to various smelters. The crude ore shipped contained 25.95 ounces of gold, 28,943 ounces of silver, and 247,858 pounds of copper. The United Copper Co. remained the most important producer in the district. Shipments were also made from the Amazon, B. & B., Browns Lake, and Copper King mines. The following notes regarding the United Copper and Copper King mines are taken from the printed report.[1]

> The year 1917 was a very trying one for the United Copper Mining Co., owing to fluctuating metal prices, labor strikes, increased operating costs, and the heavy loss we sustained through being compelled to ship our product to the Tacoma smelter through a greater part of the year. * * *
>
> A labor strike in the British Columbia coal fields in March compelled the Trail smelter to discontinue smelting copper ore on account of failure of coke supply. From March 15 to September 15 our shipments went to the Tacoma smelter, but the settlement basis was not as favorable as our contract at Trail, resulting in a heavy loss to our company during this period.
>
> In July our mine employees called a strike for higher wages, which we could not afford to pay, and it was several weeks before we were able to secure full crews again. In September we renewed our shipments to the Trail smelter, but on November 14 their smelter employees walked out on strike and our shipments were again diverted to the Tacoma smelter. * * *
>
> But with all the handicaps, we are able to report most encouraging progress for the year. The 2-compartment shaft which was started at the close of 1916 has been sunk to the 1,300 level, that is, 300 feet below the 1,000 level, where a big hoisting station has been cut out. Drifts and raises have been run on each 100-foot level as the shaft was sunk, and very good ore is found at all points.
>
> The Copper King mine, adjoining the United Copper on the north, has been acquired on a working bond at a price and on terms that will permit of making all payments from the earnings from the King ores, and will require no money to be diverted from the United Copper earnings. * * *
>
> To meet the imperative demands on our milling capacity to handle a much greater tonnage of our low-grade ores it was found necessary to install additional equipment, and our two mills can now handle from 350 to 400 tons daily throughout the coming year.

A summary of the available ore gives 293,985 tons for the United Copper mine and 100,000 tons for the Copper King mine, from which the estimated yield is 714,190 ounces of silver and 10,101,320 pounds of copper. The mine produced 1,147,014 pounds of copper and 147,573 ounces of silver, and the gross smelter returns were $354,372. Mining and milling cost $198,756; freight, $23,490; and treatment, $18,453. Dividends paid in 1917 amounted to $100,000, but the indebtedness at the end of the year was $61,577.

---

[1] United Copper Mining Co. Twelfth Ann. Rept., for year ending Dec. 31, 1917.

Clugston Creek district.—A test shipment of lead ore from the Neglected group was made to the Northport smelter.

Colville district.—A small output of slag was shipped from the Old Dominion smelter dump.

Loon Lake district.—Shipments of a good grade of copper ore were continued from the Loon Lake property in 1917. The operations were somewhat hampered by the labor troubles at the Canadian smelters. The shaft was sunk from the 200-foot to the 500-foot level and about 700 feet of drifts were run. Dividends in 1917 amounted to $43,352. Early in 1918 the company planned a concentration mill.

Marcus district.—The Napoleon mine, formerly an important producer, made only a few shipments of iron sulphide ore, to be used as a flux at the plant of the Canada Copper Co., at Greenwood, B. C. There was a decrease of several thousand tons of ore from the shipments made in 1916.

Northport district.—Ten deep mines produced 15,789 tons of ore, $74 in gold, 3,248 ounces of silver, 535 pounds of copper, and 9,465,046 pounds of lead, valued in all at $816,890, or $51.74 per ton. This was a decided increase from 10,223 tons of ore, valued at $45.16 per ton, in 1916. Several prospects in the district developed into shipping mines during the year. The largest production and the main increase came from the Electric Point mine, but a good production also came from the Gladstone property. Smaller shipments were made from the Coyote, W. J. Bryan, Iroquois, Lead Trust, and United Treasure mines. The Great Western and Last Chance mines, formerly operated by the Norman Mines Co., on lease, were idle during 1917. This accounts for the decrease in shipments of lead-zinc ore from the county. The Electric Point mine was operated at a loss in 1916, but in 1917 the company received $553,523 from the sale of ore. Dividends paid amounted to $166,687, including $86,558 paid from capital. The following paragraphs are taken from the printed statement.[1]

> Our engineers estimate that on December 31, 1917, we had 15,000 tons of ore blocked out. Since December 31, 1917, we have reached the 700-foot level and opened up a fine body of ore.
>
> We are expecting to build a tramway as soon as possible, to cost not to exceed $50,000.
>
> We have not paid any dividends since September 30, 1917, and have not shipped any ore since November 1, 1917, as we were behind with our development work and may have to use the surplus to provide transportation facilities.

Most of the ore is oxidized, though shipments of high-grade galena were also made. The mine is opened by shaft to the 700-foot level.

The Northport Smelting & Refining Co. operated three blast furnaces on lead ore, treating material from the Hercules mine at Burke, Idaho, and the Tamarack and Custer mines at Sunset, Idaho, and siliceous ore from Republic and custom ore from other mines. The plant is credited with a production of 45,000 tons of lead bullion in 1917, and a charge of 400,000 tons for the year. To reduce the loss of metals in the fumes a Cottrell precipitating plant was installed during the year.

---

[1] Electric Point Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

Orient district.—A small shipment of rich gold ore was made from the F. H. C. mine and of lead ore from the Old Tenderfoot property.

Spokane Indian Reservation district.—Initial shipments of copper ore were made from the O-Lo-Lim copper mine near Miles, Wash. The property was operated about seven months and is opened by a 100-foot shaft.

Springdale district.—The Copper Butte property made a few test shipments of very low-grade copper ore. Small shipments were also made from the Golden Seal and Rambler properties.

Valley district.—A shipment of sulphide copper ore was made from the Admiral property and an oxidized copper ore from the Edna mine, operated by the Valley Mining Co.

WAHKIAKUM COUNTY.

Some placer gold was shipped from the vicinity of Grays River.

WHATCOM COUNTY.

Five deep mines produced 10,897 tons of siliceous ore, containing $137,382 in gold and 2,500 ounces of silver, having a total value of $139,442. Compared with 1916, this was a slight increase in both the quantity of ore treated and the amount of gold recovered. Most of the ore was treated by amalgamation, only 42 tons having been shipped directly to the smelters.

Mount Baker district.—The entire county production came from this district. The Boundary Red Mountain Mining Co. continued to treat gold ore at its 10-stamp mill equipped from amalgamation. The mine is opened by two adits, one 500 feet and the other 1,300 feet long. The Lone Jack mine of the Boundary Gold Co. also treated several hundred tons of ore by amalgamation.

YAKIMA COUNTY.

A small test shipment of copper ore was made from the Red Bird mine in Bumping Lake district.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN ARIZONA.[1]

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

GENERAL STATEMENT.

The mines of Arizona produced in 1917 gold, silver, copper, lead, and recoverable zinc contained in bullion, ore of shipping grade, and concentrates and valued at $209,393,802. The value of the output, compared with that of 1916, increased $18,587,632, or 9.74 per cent. There were 452 producers from deep mines and 32 producers from placers, as against 504 deep-mine and 23 placer producers in 1916. The increase in the value of the metal output in 1917 was principally in copper; there was also an increase in the value of gold, silver, and lead. Dividends were paid in 1917 by 18 companies and amounted to $47,216,611. This does not include dividends from the Copper Queen mine, which were included in the combined dividends, amounting to $10,800,000, of the Phelps-Dodge Corporation, operating in Arizona, Mexico, and New Mexico.

Mine production of gold, silver, copper, lead, and recoverable zinc in Arizona in 1916 and 1917.

Year.	Number of producers	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	527	17,033,810	$3,985,559	7,212,039	721,833,169	27,062,087	19,677,949	$190,806,170
1917	484	15,770,193	5,068,193	6,983,913	712,166,891	23,465,445	20,894,860	209,393,802
Increase or decrease, 1917	−43	−1,263,617	+1,082,634	−228,126	−9,666,278	−3,596,642	+1,216,911	+18,587,632

[a] Includes placer production.

ORE.

The production of 15,770,193 short tons of ore in 1917 was 1,263,617 tons less than the output in 1916. The total average value per ton increased from $11.20 in 1916 to $13.28 in 1917, and the gold and silver value per ton increased from 51 cents to 69 cents. The dry or siliceous ores decreased from 336,304 tons in 1916 to 317,716 tons in 1917. This classification includes 236,585 tons of siliceous gold ore, averaging $11.25 in gold, 1.27 ounces of silver, 2.6 pounds of copper, and 1.14 pounds of lead to the ton. These ores were principally from Mohave, Yavapai, and Cochise counties. There was only 1 ton of siliceous material classified as gold and silver ore. The siliceous silver ores produced in 1917 aggregated 80,817 tons, averaging per ton 82 cents in gold, 6.75 ounces of silver, 2.75 pounds of copper, and 0.49 pound of lead. These ores were produced chiefly in the Turquoise and Tombstone districts of Cochise County.

---

[1] The statistical tables in this report were compiled by Bessie N. Patchell, of the United States Geological Survey.

The copper ore mined by 258 producers aggregated 15,245,297 tons, against 16,491,971 tons mined by 272 producers in 1916. The larger part of the copper ore mined, or 9,976,461 tons, was from low-grade disseminated deposits near Globe, Ray, and Ajo, where most of the ore was treated. The richer siliceous ore or that valuable as converter lining was shipped to various smelters. There was also similar disseminated ore, 1,213,197 tons in quantity, mined and milled from the low-grade copper deposits in the Clifton and Mōrenci camps of Greenlee County. Altogether the output of disseminated ores aggregated 11,189,658 tons and yielded 284,100,353 pounds of copper, or nearly 40 per cent of the total output of the State. There were mined and smelted directly (without previous concentration) 3,679,576 tons of crude copper ores, averaging 46 cents in gold and 1.17 ounces of silver per ton and 5.58 per cent of copper, with an average value of $31.86 a ton, against 3,701,716 tons in 1916, with an average value of $26.86 a ton. Of the copper ores smelted directly, 2,771,597 tons were sulphides, averaging 57 cents in gold and 1.36 ounces of silver per ton and 6.13 per cent of copper and having an average value of $35,18 a ton. The oxidized copper ore smelted, 907,979 tons in quantity, contained 12 cents in gold and 0.59 ounce of silver per ton and 3.87 per cent of copper and was valued at $21.74 a ton. There was a decrease in the quantity of lead ores smelted, which amounted to 45,940 tons in 1917, against 46,930 tons in 1916. The larger part, or 40,566 tons, was oxidized, and 5,374 tons was sulphide ore. The oxidized ores contained $2.41 in gold and 11.25 ounces of silver per ton, 0.76 per cent of copper, and 16.96 per cent of lead and had a total average value of $45 a ton. The sulphide lead ores contained $1.89 in gold and 15.85 ounces of silver per ton, 0.98 per cent of copper, and 18.42 per cent of lead. The quantity of zinc ores mined increased from 52,652 tons in 1916 to 62,839 tons in 1917. Of this ore, 5,190 tons, mainly sulphide ores, were shipped crude to smelters. The remainder of the zinc ore was concentrated and yielded 11,627 tons of concentrate. The lead-zinc ore amounted to 49,071 tons, of which 2,051 tons, mostly sulphide crude ore, was shipped to smelters, and 47,020 tons of ore were concentrated and yielded 13,145 tons of zinc concentrate, 9,300 tons of lead concentrate, and 382 tons of lead-zinc concentrate. The copper-lead ore, all of which was shipped to the smelter, amounted to 1,610 tons in quantity. The larger part (965 tons) was sulphide, there being only 645 tons classified as oxidized. The sulphide ores contained 46 cents in gold and 20.70 ounces of silver per ton, 4.66 per cent of copper, and 11.54 per cent of lead and had an average value of $62.53 a ton. There were 6,832 tons of copper-zinc ore and 4,543 tons of old tailings concentrated, which yielded 1,523 tons of copper concentrate, 524 tons of copper-zinc concentrate, and 740 tons of zinc concentrate.

Ore and metals produced in Arizona in 1917.

Source of production.	Number of producers	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.
		Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	32	....	832.73	227	....	....	....
Dry or siliceous ore	121	317,716	131,997.57	848,500	829,737	309,219	....
Copper ore	258	15,245,297	98,530.97	5,214,411	710,067,644	60,287	....
Lead ore	86	82,285	5,739.02	553,544	726,779	16,289,714	....
Zinc ore	8	62,839	4,078.35	116,179	143.193	181,420	10,618,248
Copper-lead ore	12	1,610	54.76	33,647	141,130	432,484	....
Lead-zinc ore	8	49,071	2,352.86	190,033	58,057	6,161,811	9,476,718
Copper-zinc ore	2	11,375	1,587.57	27,372	200,351	30,510	799,894
	......	15,770,193	245.173.83	6,983,913	712,166,891	23,465,445	20,894,860

Ore sold or treated in Arizona in 1917, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-zinc. ore.	Total.
Cochise	95,248	1,784,050	34,071	....	29	1,535	....	1,914,933
Coconino	....	1,511	....	....	....	....	....	1,511
Gila	147	6,048,653	688	52	4	....	....	6,049,544
Graham	36	10,745	1,766	....	27	....	....	12,574
Greenlee	57	1,431,061	....	....	....	....	....	1,431,118
Maricopa	615	916	21	....	....	....	....	1,552
Mohave	168,376	3,162	2,084	58,163	....	43,780	....	275,565
Pima	851	992,422	1,619	44	457	516	....	995,909
Pinal	4,489	3,761,484	32,531	18	209	....	....	3,798,731
Santa Cruz	128	47,708	3,843	4,027	876	3,240	5,057	64,879
Yavapai	47,363	1,120,448	1,980	535	....	....	6,318	1,176,644
Yuma	406	43,137	3,682	....	8	....	....	47,233
	[a]317,716	15,245,207	82,285	62,839	1,610	49,071	11,375	15,770,193
Value per ton in gold and silver	$10.79	$0.41	$6.98	$2.86	$17.92	$4.18	$4.87	$0.68

[a] Includes 236,585 tons of gold ore, 1 ton of gold and silver ore, 80,817 tons of silver ore, and 313 tons of iron ore.

GOLD.

In 1917 Arizona ores, placer dust, and bullion yielded 245,173.83 ounces of gold, valued at $5,068,193. Of this value, $17,214, against $14,281 in 1916, came from placers; $2,728,632, against $1,517,616 in 1916, came from dry or siliceous ore; and $2,036,816, against $2,180,211 in 1916, came from copper ores. The mines of Mohave County produced the largest output of gold—$2,463,178 in 1917, against $1,038,814 in 1916. Cochise County was second, with a production of $1,149,782, against $1,514,811 in 1916. The United Eastern and Tom Reed mines were the largest contributors in Mohave County, the Calumet & Arizona and Copper Queen in Cochise County, and the United Verde and Copper Chief in Yavapai County. Gold recovered from ores treated in gold and silver mills represented about 49 per cent of the total production, and crude ores shipped to smelters about 39 per cent. From ores treated in mills by amalgamation the gold recovered amounted to $38,759, and that from ores treated by cyanidation to $2,455,019. Concentrates contained $542,446, as against $405,500 in 1916, and ores shipped directly to smelters contained $2,003,570, against $2,129,500 in 1916. The chief producing districts in 1917 were the San Francisco district in Mohave County, where siliceous gold ores were produced, the Warren district in Cochise County, where copper ores were produced, and the Verde district in Yavapai County, producing both siliceous and copper ore.

Of the mines producing gold in 1917 the United Eastern, at Oatman, was first, with 86,629.41 ounces from siliceous ore. The United Verde Copper mine was second, followed by the Calumet & Arizona, at Bisbee, the Tom Reed, at Oatman, the Copper Queen, at Bisbee, the Blue Bell, in Yavapai County, and the Magma, in Pinal County. Altogether these seven properties yielded about 80 per cent of the total gold.

Mine production of gold in Arizona in 1917, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-zinc ore.	Total.
Cochise		4,085.48	48,550.77	2,984.45					55,620.70
Coconino			1.11						1.11
Gila		63.14	5,669.66	402.69					6,135.49
Graham		26.30	13.56	12.95		2.00			54.81
Greenlee		23.02	2,527.99						2,551.01
Maricopa	149.38	1,136.66	256.99	3.28					1,546.31
Mohave		112,251.83	45.78	599.34	4,073.00		2,186.29		119,156.24
Pima	231.14	54.29	55.01	3.68		21.26			365.38
Pinal		92.09	7,235.12	580.96		4.00			7,912.17
Santa Cruz		9.67	33.95	14.00		27.50	166.57		251.69
Yavapai	181.99	13,698.53	32,899.37	1,137.26	5.35			1,587.57	49,510.07
Yuma	270.22	556.56	1,241.56	.41					2,068.85
	832.73	[a]131,997.57	98,530.97	5,739.02	4,078.35	54.76	2,352.86	1,587.57	245,173.83

[a] Includes 128,801.16 ounces from gold ore, 3.62 ounces from gold and silver ore, and 3,192.79 ounces from silver ore.

SILVER.

Silver produced from mines in Arizona decreased from 7,212,039 ounces in 1916 to 6,983,913 ounces in 1917. The value, however, increased from $4,745,522 to $5,754,744 on account of the increased price of the metal. Of this output, 5,214,411 ounces came from copper ore, 848,500 ounces from dry or siliceous ore, 553,544 ounces from lead ore, 190,033 ounces from lead-zinc ore, and smaller quantities from zinc, copper-lead, and copper-zinc ores. The greatest increase of silver was in Yavapai, Santa Cruz, Pinal, and Mohave counties, principally from copper ores. Bullion recovered from gold and silver ores, principally by cyanidation (252,652 ounces), yielded 254,353 ounces of silver in 1917. Concentrates contained 1,271,890 ounces, and crude ore shipped to smelters contained 5,312,292 ounces, representing more than 76 per cent of the total output. Cochise County mines led in output of silver, producing 2,707,220 ounces of silver in 1917, against 3,709.225 ounces in 1916, 3,034,714 ounces in 1915, 2,753,953 ounces in 1914, and 2,127,171 ounces in 1913. Yavapai County produced 2,207,583 ounces of silver in 1917, against 1,735,302 ounces in 1916.

Nearly half of the total silver came from the ore of four important copper properties. The United Verde was first in 1917, followed by the Calumet & Arizona and the Copper Queen, both at Bisbee, and the Magma, in Pinal County.

Mine production of silver in Arizona in 1917, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-zinc ore.	Total.
Cochise		522,688	1,806,240	378,263		29			2,707,220
Coconino			4,576						4,576
Gila		19,092	476,816	5,147		865			501,920
Graham		1,212	3,031	28,886		195			33,324
Greenlee		704	82,754						83,458
Maricopa	24	490	2,198	42					2,754
Mohave		75,363	4,770	26,773	90,104		173,084		370,094
Pima	120	358	145,801	13,863		7,492			167,634
Pinal		532	665,436	4,900		9,071			679,939
Santa Cruz		8,572	111,500	35,380	23,507	15,446	16,949	7,429	218,783
Yavapai	22	218,971	1,909,194	56,885	2,568			19,943	2,207,583
Yuma	61	518	2,095	3,405		549			6,628
	227	[a]848,500	5,214,411	553,544	116,179	33,647	190,033	27,372	6,983,913

[a] Includes 302,808 ounces from gold ore, 114 ounces from gold and silver ore, and 545,578 ounces from silver ore.

COPPER.

The production of copper from Arizona mines amounted to 712,166,891 pounds, valued at $194,421,561, in 1917, against 721,833,169 pounds, valued at $177,570,960, in 1916. There was, therefore, a decrease of 9,666,278 pounds in quantity and an increase of $16,850,601 in value. Crude ore shipped directly to the smelters yielded 412,030,793 pounds, or nearly 58 per cent of the total quantity, against 385,569,908 pounds in 1916. Of the output from crude ore smelted in 1917, Cochise County produced about 43 per cent. Yavapai, Gila, Pima, Greenlee, and Pinal counties also produced large quantities. The copper in concentrates produced at milling plants decreased from 331,133,062 pounds in 1916 to 282,146,701 pounds in 1917. This decrease was due principally to labor strikes in Gila and Cochise counties. Gila County, including the Globe and Miami districts, produced altogether 141,554,598 pounds in concentrates, against 189,299,027 pounds in 1916, 77,085,710 pounds in 1915, 73,488,162 pounds in 1914, 71,609,847 pounds in 1913, 63,969,423 pounds in 1912, and 49,226,341 pounds in 1911. The low-grade disseminated ores in Pima, Pinal, and Gila counties yielded 146,547,980 pounds of copper, against 244,675,654 pounds in 1916, 124,264,911 pounds in 1915, 95,485,293 pounds in 1914, 87,073,406 pounds in 1913, 68,753,553 pounds in 1912, and 30,666,515 pounds in 1911. Similar low-grade copper deposits exist in Greenlee County, whose output added made the total production from the disseminated deposits in Arizona 284,100,353 pounds, or nearly 40 per cent of the aggregate output in 1917. In 1916 these ores altogether produced 299,704,303 pounds of copper.

Thirteen properties produced about 88 per cent of the total quantity of copper, each of them yielding over 10,000,000 pounds. The Copper Queen, at Bisbee, was first, with 93,618,409 pounds, followed by the Ray Consolidated, in Pinal County, with 88,582,649 pounds; Inspiration, at Globe, with 80,566,982 pounds; and United Verde, in Yavapai County. Those closely following were the United Verde Extension, Calumet & Arizona, Miami Copper, Arizona Copper, Old Dominion, New Cornelia, Detroit Copper, Shattuck, and Magma.

Mine production of copper in Arizona in 1917, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-zinc ore.	Total.
Cochise	216,409	176,093,792	502,938	....	1,842	....	....	176,814,981
Coconino	....	346,538	....	....	....	....	....	346,538
Gila	....	175,380,380	2,099	....	1,147	....	....	175,383,626
Graham	283	420,660	66,903	....	1,418	....	....	489,264
Greenlee	143	53,072,187	....	....	....	....	....	53,072,330
Maricopa	188	81,090	127	....	....	....	....	81,405
Mohave	2,321	828,211	12,141	....	....	55,300	....	897,973
Pima	....	34,782,224	56,963	....	38,256	....	....	34,877,443
Pinal	....	102,877,626	2,600	....	32,166	....	....	102,912,392
Santa Cruz	2,746	3,693,677	81,266	137.843	65,756	2,757	117,131	4,101,176
Yavapai	602,738	158,919,096	1,742	5,350	....	....	83,220	159,612,146
Yuma	4,909	3,572,163	....	....	545	....	....	3,577,617
	[a]829,737	710,067,644	726,779	143,193	141,130	58,057	200,351	712,166,891

[a] Includes 604,040 pounds from gold ore, 222,566 pounds from silver ore, and 3,131 pounds from iron ore.

LEAD.

The mine production of lead in Arizona in 1917 was 23,465,445 pounds, valued at $2,018,028, against 27,062,087 pounds, valued at $1,867,284, in 1916, a decided decrease in quantity but an increase in value. Cochise County, principally the Warren or Bisbee district, although responsible for the decrease in quantity, had the largest yield of lead, or 11,262,440 pounds, valued at $968,570, as against 15,902,137 pounds, valued at $1,097,247, in 1916. Mohave County followed with 6,141,246 pounds, Santa Cruz County with 1,839,390 pounds, and Graham County with 1,488,711 pounds. Concentrates derived from low-grade ores produced 6,751,858 pounds of lead, and crude ores shipped directly to smelters produced 16,713,587 pounds.

Five properties produced about seven-tenths of the lead, the Copper Queen, at Bisbee, leading with 6,870,128 pounds, followed closely by the Tennessee, at Chloride, and by lesser quantities from the Shattuck-Arizona, at Bisbee, the Grand Reef, in Graham County, and the Bunker Hill, at Tombstone.

Mine production of lead in Arizona in 1917, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-zinc ore.	Total.
Cochise	260,609	903	10,795,424	....	4,433	201,071	....	11,262,440
Gila	1,176	418	184,804	....	817	....	....	187,215
Graham	....	....	1,473,075	....	15,636	....	....	1,488,711
Maricopa	1,715	31,907	12,110	....	....	....	....	45,732
Mohave	11,303	....	770,079	....	....	5,359,864	....	6,141,246
Pima	....	....	518,191	....	117,064	51,764	....	687,019
Pinal	....	26,212	822,690	....	76,579	....	....	925,481
Santa Cruz	9,991	207	888,874	160,020	217,176	549,112	14,010	1,839,390
Yavapai	24,425	640	623,909	21,400	....	....	16,500	686,874
Yuma	....	....	200,558	....	779	....	....	201,337
	[a]309,219	60,287	16,289,714	181,420	432,484	6,161,811	30,510	23,465,445

[a] Includes 269,441 pounds from gold ore and 39,778 pounds from silver ore.

ZINC.

The mine output of recoverable zinc from Arizona zinc-bearing ores in 1917 amounted to 20,894,860 pounds, valued at $2,131,276, against 19,677,949 pounds, valued at $2,636,845, in 1916. There was an increase of more than 6 per cent in quantity but a decrease in the value of the output on account of the lower price of zinc. Most of the zinc ore and lead-zinc ore was mined in Mohave County at Union Pass and Chloride. Santa Cruz and Yavapai counties contributed zinc from both zinc ore and copper-zinc ore. Ores milled yielded 17,817,501 pounds of zinc from concentrates, the remainder being from first-class or shipping ore. Smaller quantities of ore containing zinc were mined in Cochise, Pima, Pinal, and Gila counties.

The three large producers of zinc in Arizona were the Golconda and Tennessee mines, in Mohave County, and the Duquesne mine, in Santa Cruz County. These properties yielded nearly 87 per cent of the total in 1917.

Mine production of recoverable zinc in Arizona, in 1917, in dry pounds.

County.	Zinc ore.	Lead-zinc ore.	Copper-zinc ore.	Total.
Cochise		608,443		608,443
Gila	35,333			35,333
Mohave	8,664,101	8,485,099		17,149,200
Pima	19,171	175,440		194,611
Pinal	11,322			11,322
Santa Cruz	1,465,919	207,736	271,534	1,945,189
Yavapai	422,402		528,360	950,762
	10,618,248	9,476,718	799,894	20,894,860

Zinc ore and concentrate from Arizona mines and mills sold in 1917.

Classification.	County.	Quantity.	Average assay of ore and concentrate.[a]
		Short tons.	*Per cent of zinc.*
Sulphide zinc ore	Mohave, Santa Cruz, and Yavapai	4,898	25.38
Sulphide lead-zinc ore	Cochise	1,473	23.04
Oxidized zinc ore	Gila, Pima, Pinal, and Santa Cruz	292	36.35
Oxidized lead-zinc ore	Cochise and Pima	578	21.07
Zinc concentrates	Mohave and Yavapai	25,512	39.90
Lead-zinc concentrates	Mohave and Santa Cruz	382	37.05
Copper-zinc concentrates	Santa Cruz	524	30.48
		33,659	36.51

[a] Actual assay content.

MINING INDUSTRY.

Miners working in the copper mines of Arizona demanded higher pay, making their first request in November, 1916, of the New Cornelia Copper Co., at Ajo, which had not started its newly erected electrolytic copper plant. This labor strike was settled in January, 1917, and was followed the last of May by similar trouble at Jerome. Further agitation was started at Bisbee in June and in the Globe-Miami district in July, causing the mines in the latter district to close for seven weeks. By this closing of the mines in the Globe-Miami district, there was a decrease in copper output of more than 15,000,000 pounds a month and in other districts a curtailment of production that greatly affected the total output of the metal. However, much of this decrease in copper was offset by the New Cornelia Co., which began to produce heavily in June and continued for the next six months with an average of about 3,000,000 pounds of copper a month. To this amount was added the increased copper output of the Imperial mine, at Silver Bell, the Magma mine, at Superior, and the important new producers at Stoddard, in Yavapai County. These activities prevented a greater decrease in copper.

There were 11 copper-smelting plants in operation in 1917, as follows: Copper Queen and Calumet & Arizona, at Douglas; Sasco smelter, near Silver Bell; American Smelting & Refining Co., at Hayden; Consolidated Arizona, at Humboldt; International, at Miami; Old Dominion, at Globe; Detroit, at Morenci; Arizona Copper and Shannon, at Clifton; and United Verde, at Clarkdale. The United Verde Extension has designed a smelting plant equipped with blast furnaces and converters for the treatment of its ore. This plant was completed in 1918.

REDUCTION MILLS.

Forty-nine milling plants of various kinds were in operation in Arizona in 1917, but only a few continuously. Two mills used straight amalgamation; 4, amalgamation and concentration; 1, amalgamation and cyanidation; 7, only cyanidation; 2, amalgamation, concentration, and cyanidation; 28, concentration, of which 8 were equipped for table concentration only, 18 for table and flotation concentration, and 2 for straight flotation only. In addition there were 2 leaching plants and 3 precipitating plants recovering copper from solutions. A list giving all the mills in commission, including many new plants under construction in 1911 and 1912, was published in Mineral Resources for 1911, Part I, page 426.

The ore treated in 1917 by amalgamation amounted to 21,100 tons and produced 1,874.99 ounces of gold and 1,701 ounces of silver, an average recovery per ton of $1.84 in gold and 0.08 ounce in silver. Ores treated by cyanidation amounted to 222,669 tons, which, with 22,709 tons of old tailings, produced 118,761.54 ounces of gold and 252,652 ounces of silver, or an average recovery per ton from ore and tailings of $10 in gold and 1.03 ounces of silver. The total value of the bullion recovered from ore and tailings was $2,703,365, as against $1,858,983 in 1916. During 1917 there were 205 pounds of quicksilver and 157,961 pounds of sodium cyanide consumed at milling plants. This corresponds to 0.057 pound of mercury per ounce of gold and silver and 0.01 pound of mercury per ton of ore treated. The consumption of cyanide was 0.43 pound per ounce of gold and silver and 0.64 pound per ton of ore and tailings treated.

Gold and silver produced at mills in Arizona in 1917.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Cochise	[a] 53,758	437.41	880	1,568.55	141,952	$159,161
Gila	37	55.61	90			1,224
Graham	8	4.30	2			91
Greenlee	27	19.02	6			398
Maricopa	428	474.43	315			10,067
Mohave	[b] 167,518	167.66	99	[c] 112,015.11	[c] 57,378	2,366,385
Pima	70	46.50	22			979
Pinal	2	[d] 91.14	[d] 135			1,995
Santa Cruz	6	4.10	5			89
Yavapai	[e] 21,886	551.67	133	[f] 5,177.88	[f] 53,322	162,487
Yuma	29	23.15	14			489
	243,769	1,874.99	1,701	118,761.54	252,652	2,703,365

[a] Also yielded 1,739 tons of concentrate.
[b] Also yielded 1 ton of concentrate.
[c] Includes bullion from 499 tons of old tailings.
[d] Includes bullion from 4,480 tons of old tailings.
[e] Also yielded 57 tons of concentrate.
[f] Includes bullion from 17,730 tons of old tailings.

Concentration plants reduced 10,943,997 tons of ore to 783,832 tons of concentrates, which were shipped to smelters and produced $542,446 in gold, 1,271,890 ounces of silver, 282,146,701 pounds of copper (or nearly 40 per cent of the total output of copper in the State), 6,751,858 pounds of lead, and 17,817,501 pounds of recoverable zinc, valued in all at $81,014,577, a total average value per ton of $103.35. Copper concentrates amounting to 745,123 tons comprised more than 95 per cent of the total concentrates produced.

Mine production of metals from Arizona concentrates in 1917.

By counties.

County.	Ore to concentrating mills.	Concentrates produced.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value of concentrates.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Cochise	6,102	2,261	559.29	52,260	65,493	356,520		$103,163
Gila	5,730,268	277,910	3,431.65	232,993	141,554,598			38,907,329
Graham	9,024	564	1.01	340	246,298			67,540
Greenlee	1,268,783	164,371	2,041.70	65,629	40,087,614			11,040,203
Mohave	76,397	33,801	6,243.92	265,622	55,542	5,454,404	16,809,871	2,546,795
Pima	779	58		220				181
Pinal	3,685,395	261,987	6,268.18	462,974	91,011,649	58,442		25,362,272
Santa Cruz	21,299	2,729	174.57	25,892	468,482	707,442	479,270	262,565
Yavapai	143,811	39,996	7,520.51	163,957	8,657,025	28,465	528,360	2,710,273
Yuma	2,139	155		2,003		146,585		14,256
	10,943,997	783,832	26,240.83	1,271,890	282,146,701	6,751,858	17,817,501	81,014,577

By kinds of concentrates.

Dry or siliceous	102	58.48	906	284			$2,032
Copper	745,123	18,646.92	922,052	282,020,820			78,136,921
Lead	12,189	2,629.76	201,406	64,117	6,676,631		812,014
Zinc	25,512	4,880.80	138,802	30,100	16,500	17,305,375	1,990,052
Copper-zinc	524		3,932	31,380	14,010	271,534	40,709
Lead-zinc	382	24.87	4,792		44,717	240,592	32,849

Of the material smelted, the crude ore was the largest part—3,782,494 tons. It contained the following quantities of recoverable metals: 96,922.70 ounces, or $2,003,570, in gold; 5,312,292 ounces of silver; 412,030,793 pounds of copper; 16,713,587 pounds of lead; and 3,077,359 pounds of zinc, valued in all at $120,616,563, or an average value per ton of $31.89. The copper ores constituted the largest part of the crude ores smelted, aggregating 3,679,576 tons, of which the Warren or Bisbee district, in Cochise County, produced more than 48 per cent. The dry or siliceous ores formed the next largest quantity—48,127 tons, followed by lead ores—45,940 tons, the latter being produced largely in the Warren district of Cochise County.

Mine production of metals from Arizona crude ore shipped to smelters in 1917.

By counties.

County.	Crude ore to smelter.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Cochise	1,832,073	52,514.41	2,367,105	175,716,928	10,905,920	608,443	$52,006,755
Coconino	1,511	1.11	4,576	346,538	....	....	98,399
Gila	318,539	2,648.23	268,709	33,754,742	187,215	35,333	9,510,908
Graham	3,542	49.50	32,982	242,966	1,488,711	....	222,559
Greenlee	153,064	490.29	17,823	12,840,937	....	....	3,530,397
Maricopa	1,124	922.50	2,415	81,405	45,732	....	47,216
Mohave	5,395	729.55	46,995	836,431	686,842	339,329	375,831
Pima	264,849	87.74	167,272	18,796,312	687,019	194,611	5,319,972
Pinal	108,854	1,552.85	216,830	11,900,743	867,039	11,322	3,535,391
Santa Cruz	41,671	73.02	192,886	3,632,694	1,131,948	1,465,919	1,399,044
Yavapai	1,008,307	36,078.02	1,990,149	150,303,480	658,409	422,402	43,518,241
Yuma	43,565	1,775.48	4,550	3,577,617	54,752	....	1,021,850
	3,782,494	96,922.70	5,312,292	412,030,793	16,713,587	3,077,359	120,616,563

By kinds of ore.

Dry or siliceous	48,127	10,082.72	399,846	740,079	42,669	....	$743,612
Copper	3,679,576	81,488.69	4,308,674	410,285,672	60,287	....	117,248,041
Lead	45,940	5,221.98	541,540	720,719	15,743,892	....	2,104,908
Zinc	5,190	74.55	28,585	143,193	181,420	2,293,476	313,724
Copper-lead	1,610	54.76	33,647	141,130	432,484	....	104,578
Lead-zinc	2,051	....	....	....	252,835	783,883	101,700

PRODUCTION BY COUNTIES.

GENERAL STATEMENT.

The following tables show the State output by counties in 1917, the production of each metal, and the total value; also the production of ore and the average value per ton, by counties, in 1916 and 1917. The tables are followed by a review of the mining industry of each county and each producing mining district.

Ore sold or treated, number of deep mines producing, and average value of ore per ton in Arizona in 1916 and 1917.

County.	Ore sold or treated, 1917.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	Quantity.	Increase or decrease.	1916	1917	1916	1917	1916	1917
	Short tons.	*Short tons.*						
Cochise	1,914,933	− 415,638	67	53	$23.67	$27.51	$1.70	$1.77
Coconino	1,511	+ 1,373	3	6	76.80	65.12	2.26	2.51
Gila	6,049,544	−1,718,146	58	50	7.19	8.01	.06	.09
Graham	12,574	+ 6,048	17	13	37.22	23.08	2.02	2.27
Greenlee	1,431,118	− 580,764	18	17	9.35	10.21	.05	.08
Maricopa	1,552	− 17,119	22	14	3.82	36.91	3.00	20.06
Mohave	275,565	+ 68,029	45	59	20.32	19.20	5.86	10.05
Pima	995,909	+ 821,924	62	61	19.74	9.78	.69	.14
Pinal	3,798,731	+ 334,724	45	26	6.28	7.61	.15	.19
Santa Cruz	64,879	+ 34,492	34	26	28.12	25.61	1.73	2.86
Yavapai	1,176,644	+ 209,066	88	75	30.19	39.58	2.25	2.41
Yuma	47,233	− 7,626	45	52	21.58	21.95	1.25	.90
	15,770,193	−1,263,617	504	452	11.20	13.28	.51	.69

[a] Placer product excluded.

Mine production of gold, silver, copper, lead, and zinc in Arizona in 1917.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.		
	Quantity.	Value.	Quantity.	Value.		Quantity.	Value.
	Fine ounces.		*Fine ounces.*			*Fine ounces.*	
Cochise			55,620.70	$1,149,782	$1,149,782	2,707,220	$2,230,749
Coconino			1.11	23	23	4,576	3,771
Gila			6,135.49	126,832	126,832	501,920	413,582
Graham			54,81	1,133	1,133	33,324	27,459
Greenlee			2,551.01	52,734	52,734	83,458	68,769
Maricopa	149.38	$3,088	1,396.93	28,877	31,965	2,754	2,269
Mohave			119,156.24	2,463,178	2,463,178	370,094	304,958
Pima	231.14	4,778	134.24	2,775	7,553	167,634	138,130
Pinal			7,912.17	163,559	163,559	679,939	560,270
Santa Cruz			251.69	5,203	5,203	218,783	180,277
Yavapai	181.99	3,762	49,328.08	1,019,702	1,023,464	2,207,583	1,819,048
Yuma	270.22	5,586	1,798.63	37,181	42,767	6,628	5,462
	832.73	17,214	244,341.10	5,050,979	5,068,193	6,983,913	5,754,744

County.	Copper.		Lead.		Recoverable zinc content.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Cochise	176,814,981	$48,270.490	11,262,440	$968,570	608,443	$62,061	$52,681,652
Coconino	346,538	94,605					98,399
Gila	175,383,626	47,879,730	187,215	16,100	35,333	3,604	48,439,848
Graham	489,264	133,569	1,488,711	128,029			290,190
Greenlee	53,072,330	14,488,746					14,610,249
Maricopa	81,405	22,223	45,732	3,933			60,390
Mohave	897,973	245,147	6,141,246	528,147	17,149,200	1,749,219	5,290,649
Pima	34,877,443	9,521,542	687,019	59,084	194,611	19,850	9,746,159
Pinal	102,912,392	28,095,083	925,481	79,591	11,322	1,155	28,899,658
Santa Cruz	4,101,176	1,119,621	1,839,390	158,188	1,945,189	198,409	1,661,698
Yavapai	159,612,146	43,574,116	686,874	59,071	950,762	96,978	46,572,677
Yuma	3,577,617	976,689	201,337	17,315			1,042,233
	712,166,891	194,421,561	23,465,445	2,018,028	20,894,860	2,131,276	209,393,802

COCHISE COUNTY.

Mine production in Cochise County, Ariz., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	69	2,330,571	[a] $1,514,811	[a] 3,709,225	203,651,911	15,902,137	72,703	$55,160,840
1917	53	1,914,933	1,149,782	2,707,220	176,814,981	11,262,440	608,443	52,681,652
Increase or decrease, 1917		−415,638	− 365,029	− 1,002,005	− 26,836,930	− 4,639,697	+535,740	−2,479,188

[a] Includes placer production.

The total average value per ton of the ore increased from $23.67 in 1916 to $27.51 in 1917, and the gold and silver value in this ore increased from $1.70 to $1.77. All the metals, with the exception of zinc, decreased in quantity and value. Gold decreased from $1,514,811 in 1916 to $1,149,782 in 1917; silver, from $2,440,670 in 1916 to $2,230,749 in 1917; copper, from $50,098,370 to $48,270,490; lead, from $1,097,247 to $968,570. Recoverable zinc, valued at $9,742 in 1916, increased to $62,061 in 1917. Ores of smelting grade, of which there were 1,832,073 tons, predominated and contained $1,085,569 in gold, 2,367,105 ounces of silver, 175,716,928 pounds of copper, 10,905,920 pounds of lead, and 608,443 pounds of zinc, valued in all at $52,006,755, or an average value per ton of $28.39. The 33,241 tons of lead ores shipped to plants outside of the State contained 2,963.45 ounces of gold, 374,325 ounces of silver, 502,048 pounds of copper, and 10,693,489 pounds of lead. Of the copper ores smelted, it was estimated that 318,108 tons were oxidized ores and 1,457,403 tons were sulphide ores. No production of placer gold was reported in 1917.

California district.—Four producers reported the output of 194 tons of ore, nearly all of which was shipped directly to the smelters, containing 334 ounces of silver, 17,410 pounds of copper, 29,057 pounds of lead, and 31,556 pounds of recoverable zinc, valued in all at $10,746, or an average value per ton of $55.39. The Cochise & Bullion property yielded a copper-lead ore and some concentrate from milling tests made on the low-grade ore dumps. It is reported that a 125-ton concentration mill for the treatment of this ore is under construction. There were small shipments also from the Horace, Gardner, and Willie Rose properties.

Cochise or Johnson district.—Nineteen producers reported the output in 1917 of 57,167 tons of ore, containing $691 in gold, 47,106 ounces of silver, 4,180,646 pounds of copper, and 15,975 pounds of lead, valued in all at $1,182,196, or an average value per ton of $20.68. All the ore except 161 tons was shipped directly to smelters, and was milled and produced some bullion and concentrate. The largest part of the output came from the Republic mines and yielded copper sulphide ore containing a little silver. The other producers of more than 500 tons of ore were the Peabody and Dragon Mountain mines.

There was also some production from the Middlemarch property, which is included in this district. The company operating the property has erected a 100-ton oil-flotation plant and shipped its first copper concentrate in 1917.

Dos Cabezas district.—The greatest part of the output of 4 producers reporting in 1917 came from the Mascot property. This ore is largely a low-grade copper sulphide containing a little silver. The Leroy and Casey properties were also producers.

Hartford or Huachuca district.—Two producers reported the output of 392 tons of ore, containing principally lead and silver, with a little copper and gold. The total value of the output was $11,490. The district is also a producer of some tungsten ore, of which no account is taken in this report.

Tombstone district.—The output of 57,474 tons of ore made by 5 producers in 1917 contained $69,721 in gold, 444,139 ounces of silver, 229,488 pounds of copper, and 1,278,754 pounds of lead, valued in all at $608,315, or an average value per ton of $10.58. The larger part of the ore, 26,762 tons, was shipped directly to the smelters, and 16,075 tons yielded gold and silver bullion and some lead concentrate. There was also 14,637 tons of old tailings shipped to the smelter, yielding principally silver, some copper, and a little gold. A considerable production came from the Bunker Hill Mines Co., operating the Tombstone group, which also produced considerable manganese ore and concentrate used at the smelter at Douglas and at metallurgic plants in the East. There were also small productions of silver ore from the Randolph, Silver Bar, and Solstice properties.

Turquoise district.—Nine producers reported a yield of 93,847 tons of ore, containing $62,372 in gold, 228,960 ounces of silver, 3,526,880 pounds of copper, and 127,887 pounds of lead, valued in all at $1,224,871, or an average value per ton of $13.05. Part of the district output of ore was milled, and 51,093 tons were shipped directly to the smelters. There were also 5,096 tons of old tailings, containing a small quantity of gold and silver, sold to the smelters as converter lining. The Commonwealth mine was the producer of the milling ore and old tailing. The Great Western Copper Co. shipped its oxidized copper ore directly to the smelter at Douglas. There were also shipments from the Leonard property, of heavy sulphide ore low in copper, which is valuable fluxing ore for the Shannon works at Clifton. The Tejon and Black Tail properties both produced ore of smelting grade.

Warren or Bisbee district.—From 10 properties in the district there was produced 1,687,112 tons of ore, containing $1,014,930 in gold, 1,966,165 ounces of silver, 167,599,046 pounds of copper, 9,725,771 pounds of lead, and 576,887 pounds of recoverable zinc, valued in all at $49,284,848, or an average value per ton of $29.21. All the ore, with the exception of 2,947 tons, was of smelting grade. There were also shipped to the smelters 3,267 tons of old slag, containing copper and silver. Most of the ore, containing copper, was treated at the two smelters at Douglas, and the lead ore was shipped to the smelter at El Paso, Tex.

The Copper Queen mines,[1] according to the annual report of the company, produced 796,502 tons of various kinds of ore, divided as follows:

Ore and metals produced at Copper Queen mines, Ariz., 1917.

Kind of material and destination.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Ounces.*	*Ounces.*	*Pounds.*	*Pounds.*
Shipped to Douglas:					
Company ore	737,729	18,339	563,493	89,235,586	....
Lease ore	35,986	59	36,533	2,932,820	....
Sacramento Hill ore	237	3	177	15,120	....
Shipped to El Paso:					
Silver-lead ore	14,658	614	209,969	428,705	6,023,858
Lease ore	2,571	117	14,178	18,909	745,248
To experimental concentrator:					
Copper ore	2,124	....	....	....	....
Lead ore	818	....	....	....	....
To Chicago:					
Manganese ore	2,379	....	....	....	....
	796,502	....	....	....	....
Miscellaneous:					
Precipitates	816	....	57	793,433	....
Old dump slag	3,267	....	205	152,121	....
	800,585	....	....	....	....
Concentrates:					
Copper to Douglas	265	3	116	40,825	....
Lead to El Paso	120	21	3,937	890	101,022
	....	19,156	828,665	93,618,409	6,870,128
Total, 1916	....	24,030	1,096,136	102,685,722	9,421,562

At the Copper Queen mine[2] the removal of Sacramento Mountain, to expose for steam shoveling a large body of low-grade disseminated ore, was commenced in 1917. This operation involves the removal and transportation to rather remote points of 8,000,000 cubic yards of overburden in order to make an estimated tonnage of 6,000,000 tons of ore available for open-pit mining. A concentrator having a capacity of 3,000 tons daily will be built at a point about 3 miles distant, in which the direct-flotation method will be followed.

From the Calumet & Arizona mines[3] 747,456 dry tons of ore were mined and shipped to various smelters, but the bulk, 721,328 tons of copper ore, was smelted at the Douglas plant. Ores high in sulphur content, 50,572 tons in quantity, were in demand at Sasco, Globe, and Miami; 3,259 tons of manganese ore went to steel manufacturers at Chicago and Birmingham; 1,607 tons of lead-zinc sulphides to Kansas paint makers; and 1,458 tons of lead ore to the smelter at El Paso. At Douglas the company smelted, in addition to its own ores, 295,286 tons of custom ore from New Mexico and Arizona mines. There was produced from the company ore sold or treated 59,131,512 pounds of refined copper, 906,038 ounces of silver, and 27,947.83 ounces of gold. Dividends paid in 1917 amounted to $7,067,241, including a distribution from capital. Altogether since 1903, including 1917, there have been paid by this company dividends amounting to $35,992,761.75. The following paragraphs were taken from the company's annual report:

> Precious metals per ton of refined copper from our own ores amounted to $43. * * *

---

[1] Phelps Dodge Corp. Ann. Rept. for year ending Dec. 31, 1917.
[2] Eng. and Min. Jour., Jan. 12, 1918, p. 58.
[3] Calumet & Arizona Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

The wages of the men have been based on a sliding scale dependent upon the price of copper, but when the Government price of 23½ cents per pound was fixed for a certain term, it was agreed that the wages established during the month of August by the price of copper for July should remain in force during the term in spite of the reduction of the selling price. During the last four months, therefore, miners' wages have been $5.35 a day and unskilled underground labor has been 25 cents less. * * *

The new reverberatory furnace was started up and is in operation. We have not sufficient waste-heat boilers for four reverberatories and have accordingly ordered two more 713-horsepower Stirling boilers similar to those now installed. The constant decrease in the amount of oxidized ores and increase in the tonnage of sulphide ores tends to the production of lower-grade mattes and greatly embarrasses us in our converter department. * * *

The steam produced from our waste-heat boilers is far more than is necessary to generate power for the entire smelting plant. Accordingly a high-tension transmission line was constructed from the smelter to the mines at Bisbee, a distance of about 24 miles. At the present time we are only sending up about 500 kilowatts of current, but as soon as the new electric pump in the Junction mine is in operation power will be furnished for it from the same source.

The Shattuck-Arizona mine[1] yielded 130,583 dry tons of copper ore shipped to Douglas and 7,992 tons of lead ore treated at El Paso. These ores contained 11,935,317 pounds of copper, 154,344 ounces of silver, 1,542 ounces of gold, and 2,010,145 pounds of lead. Dividends have been paid since July 20, 1910, amounting to $6,562,500, of which $1,575,000 was paid in 1917. The company's report contains the following paragraphs:

Every effort is being made to increase mine output, but progress has been slow owing to lower average grade of ore mined and inability to obtain satisfactory results from the small amount of development work performed. Copper ore reserves have been depleted during the last seven months of the year, due largely to the decrease in the amount of development work and negative results from the work actually accomplished. Promising leached-ore territory has been opened up, but without finding commercial ores, although the showings of leached ground are sufficient to justify the expectation of opening up good ore-bearing ground during the coming year.

Good progress has been made in exposing additional tonnages of lead-silver siliceous ores in the upper levels of the mine, especially at the 100-foot level. With the siliceous lead-silver ores we have found tonnages of high-grade copper ores, which will become available as soon as milling operations of the lead ores are started.

The increase in cost per pound of copper was due to a great extent to the decrease in labor efficiency on account of strike troubles, less metal recovery due to our mining of lower-grade ores, and in a lesser degree to the greater cost of supplies.

A very promising ore deposit was opened up during the past year on the 100-foot level. The lens of ore is high-grade copper ore associated with lead-silver values of sufficient grade to prevent mining the copper at this time without sacrificing the lead-silver values. * * *

Shipments of high-grade lead ores have been made at the rate of 150 tons per week. A much larger tonnage could have been shipped had the custom smelter at El Paso been able to treat and market these ores. The embargo has been a handicap to our operations in the lead-bearing section of the property. Important additions have been made to the low-grade siliceous lead-silver ores, and a method has been developed for realizing a good profit from the treatment devised for these ores. During the year 1916 laboratory experiments had been conducted and indicated a substantial profit could be made by concentration and flotation. During the months of February and March, 1917, actual milling tests at the rate of 50 tons daily were carried out in the Copper Queen experimental mill. This work resulted in showing that 92 per cent of the lead and 80 per cent of the silver values could be recovered at a profit of at least $4 per ton of ore treated under normal prices for lead and silver.

---

[1] Shattuck-Arizona Cooper Co. Ann. Rept. for year ending Dec. 31, 1917.

Plans and specifications for a milling plant capable of treating 400 tons per day were prepared during the year, and the building of this plant is now progressing very rapidly. Machinery has been ordered and if delivered promptly on agreed dates the plant should be ready for operation May 1, 1918.

COCONINO COUNTY.

Francis district.—All the ore shipped by 4 producers was of smelting grade, valued at $11,181, or an average value per ton of $29.74, principally for its copper content. The H. P. & Royal claims and the May Queen property were the largest producers; both marketed low-grade copper ore. There was also some ore shipped by lessees from other properties.

Grand Canyon district.—Lessees on the Grand Canyon Copper mine shipped two cars of copper ore of good grade during 1917.

White Mesa district.—The Navajo Copper Co. in 1917 purchased machinery for a mill, which had not been completed at the end of the year. Considerable copper ore was shipped for treatment to the smelters at El Paso, Tex., and Tacoma, Wash.

GILA COUNTY.

Mine production in Gila County, Ariz., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	58	7,767,690	$113,614	508,576	225,110,898	232,602	59,646	$55,849,581
1917	50	6,049,544	126,832	501,920	175,383,626	187,215	35,333	48,439,848
Increase or decrease, 1917	......	−1,718,146	+13,218	−6,656	−49,727,272	−45,387	−24,313	−7,409,733

The total average value per ton of the ore sold or treated in Gila County increased from $7.19 in 1916 to $8.01 in 1917, and the gold and silver value from 6 cents to 9 cents a ton. The output of gold, valued at $113,614 in 1916, increased to $126,832 in 1917; silver increased in value from $334,643 to $413,582; copper decreased from $55,377,281 to $47,879,730; and lead increased from $16,050 to $16,100. There was also a production of zinc in 1917 valued at $3,604. Of the ores produced, 5,730,268 tons were of concentrating grade and produced 277,910 tons of concentrate, containing 3,431.65 ounces of gold, 232,993 ounces of silver, and 141,554,598 pounds of copper. The crude ores, mostly copper ore, shipped directly to the smelters amounted to 318,539 tons, against 351,021 tons in 1916. The crude ores in 1917 contained 2,648.23 ounces of gold, 268,709 ounces of silver, 33,754,742 pounds of copper, 187,215 pounds of lead, and 35,333 pounds of zinc. There were also 700 tons of old copper slag smelted. Nearly all of the ore produced was treated in the district, with the exception of lead ores and some copper ores, which were shipped to plants outside of the county. Of the copper ores smelted, 93,817 tons were oxidized and 223,868 tons were sulphides. The smelting ores shipped were valued at $9,510,908, or an average value per ton of $29.86, and the concentrates, chiefly copper, were valued at $38,907,329, or an average value per ton of $139.99.

Banner district.—Eight properties were producers of 101,728 tons of ore, containing $21,334 in gold, 28,788 ounces of silver, 5,888,057 pounds of copper, 113,496 pounds of lead, and 35,333 pounds of recoverable zinc, valued in all at $1,665,860, or an average value per ton of $16.38. All of this ore was of smelting grade with the exception of 20 tons, which yielded a small quantity of gold bullion. The Christmas property was the principal producer of copper ore treated at the Hayden smelter. This property is opened by a vertical shaft 850 feet deep. The Gila Canyon property was next in importance as a shipper of copper ore. From the Lavell mine considerable oxidized lead ore was shipped to El Paso. The London-Arizona yielded copper ore and a small quantity of oxidized zinc ore.

Brown district.—A small quantity of oxidized copper ore was shipped from the Bell Copper prospect to the Globe smelter.

Dripping Springs district.—The Cow Boy property yielded a small quantity of gold bullion from milling operations and one lot of oxidized lead ore, which was shipped to a smelter.

Globe-Miami district.—Thirty-six properties produced 5,947,681 tons of ore, the larger part of which (5,730,268 tons) was of milling grade and yielded 277,910 tons of concentrate containing 3,431.65 ounces of gold, 232,993 ounces of silver, and 141,554,598 pounds of copper. The smelting ore amounted to 216,713 tons, containing 1,635.17 ounces of gold, 221,210 ounces of silver, 27,862,512 pounds of copper, and 65,010 pounds of lead. In addition to this ore, there were 700 tons of old slag smelted, which contained copper and silver.

Recent developments reported[1] in the district are of importance.

> The development of high-grade copper ore on the 1,000-foot level at Iron Cap indicates an exceptionally important strike for the Globe district and lends much encouragement to the exploration that Old Dominion, Commercial, and Superior-Boston have been carrying on at depth, with attendance of good results. The outlook is also improved for New Dominion and several other developing properties. Iron Cap ore is in bornite and on the 1,000-foot level averages 12.5 per cent copper with about 10 ounces silver. On the 800-foot level the ore has an average width of 8 feet and on the 900-foot of 12 feet and carries 10 per cent copper. Sinking from the 1,000 to 1,100-foot has been started. Arizona Commercial is opening new stopes between the 1,500 and 1,400 foot levels and pushing development vigorously with good results on the 800, 1,000, 1,200, and 1,500 foot levels. The water area has been lowered between the 1,200 and 1,500 foot levels. Porphyry Copper Co. is to block out ore, preparations being under way to cut stations at 530 feet and 630 feet in the shaft and start driving.

The Old Dominion mine[2] and the United Globe mines, combined in 1917 under one company, produced 199,888 dry tons of ore, averaging 4.97 per cent of copper. This included 81,728 tons of smelting ore averaging 6.92 per cent of copper, 114,217 tons of concentrating ore averaging 3.62 per cent of copper, 3,904 tons of siliceous ore averaging 3.29 per cent of copper, and 39 tons of iron ore averaging 2.21 per cent of copper. The total production of metal in 1917, including that from custom ores, was 32,365,795 pounds of refined copper, 165,703 ounces of silver, and 3,897.60 ounces of gold. The mining costs per ton in 1917 were $8.08, against $6.48 in 1916, and milling costs were $1.25, against $1.14. The metal extraction for 1917 was 88.01 per cent, as compared with 86.63 per cent in 1916. Of the total extraction, 30.54 per cent was made by flotation, 69 per cent by water concentration, and 0.46 per cent from overflow slimes sent to the smelter. Dividends have been paid since 1905 by the companies operating these properties amounting to $13,216,976, of which $2,376,262 was paid in 1917.

---

[1] Min. and Sci. Press, Jan. 26, 1918, p. 136.

[2] Old Dominion Co. Ann. Rept. for year ending Dec. 31, 1917.

In 1917 the Inspiration mine[1] produced 3,914,742 tons of ore, against 5,353,880 tons mined in 1916. Of the ore mined, 3,891,075 tons were concentrated and yielded 0.0359 ton of concentrate per ton of ore treated. There were 23,677 tons of oxidized ore shipped to the smelter. The total production of copper was 80,566,982 pounds, against 120,772,637 pounds in 1916. The total cost of copper derived from concentrating ores was 10.43 cents a pound and the total cost per ton of ore was $2.01. The dividends paid in 1917 amounted to $9,751,227.75. The company's annual report says:

> The production of the company for the first half of the year was 12.9 per cent above the average for a like number of months in the previous year. The operations during the later part of the year were interrupted by a strike brought about simultaneously in the first days of July by agents of the I. W. W. and the International Union of Miners, Mill, and Smelter Workers. Work was resumed in the mine on August 23, and the mill started on September 1. On October 20 the strike was declared off, we having at that date 968 men in our employ, most of the draft men and the other Americans having previously returned to work. * * *
>
> The local increase in the cost of producing copper for the year as against the previous one has been due to the interruption of the strike, the increased prices paid for labor and material, the increased State and county taxes, and the decreased yield from the ore treated. The ore yielded 22.46 pounds per ton in 1916, and 20.39 pounds in 1917. This result was mainly due to the active working of a new stope, which was not in commission in 1916, yielding ore of a satisfactory margin at present prices of copper but of a lower grade than the average. The percentage of copper recovered from the ore by the concentrator was practically the same as last year, which indicates slightly better work in view of the lower grade of ore treated.

The Miami property[2] produced 1,640,206 tons of ore, which yielded 53,639 tons of concentrates containing 46,172,322 pounds of copper, or an average of 860.8 pounds a ton, representing a mill recovery of 69.25 per cent. The smelter returned 43,863,699 pounds, or 95 per cent of the total content, as merchantable copper. The total cost of handling the ore in 1917 was $2.28 a ton, divided into mining, $1.267; milling, $0.691; and general expense, $0.325, or a total average per pound of copper of $0.125. The total dividends paid by this company since 1912 amounted to $16,233,030.75, of which $6,537,247.50 were paid in 1917. The following extracts are from the company's report:

> During the first six months of the year production continued on the scale reached by the end of 1916 at the rate of about 6,000 tons of ore per day and a monthly output of 5,000,000 pounds of refined copper. For the last few months of this period labor unrest was evident, and it culminated in a strike on July 2, as a result of which operations were very much hampered for the balance of the year. The property was closed down for seven weeks, when work was resumed and continued on a gradually increasing scale until by the end of the year normal conditions were again reached. * * *
>
> An important step affecting the mine was taken by the decision to sink a new working shaft known as shaft No. 5. Up to the present time shaft No. 4 has been the only outlet for ore from the mine, and the crushing plant at this point has been barely able to handle the output under continuous op-

---

[1] Inspiration Consolidated Copper Co. Ann. Rept. for the year ending Dec. 31, 1917.

[2] Miami Copper Co. Ann. Rept. for year ending Dec. 31, 1917.

eration. The new shaft will be lined with concrete in place of timber and thus be fireproof, and complete hoisting equipment and a second crushing plant will be installed. * * * The new shaft will have a total depth of 830 feet and will be connected with the ore-producing portion of the mine at the 570 and 720 foot levels, where underground ore pockets will be located. * * *

Underground development work done during the year amounted to 25,476 feet, consisting of 10,457 feet of drifts. 14,993 feet of raises, and 26 feet for the new working shaft. * * *

No additional tonnage of high-grade ore has been developed, and at the end of the year the reserves of this class stand at 14,760,000 tons (2.40 per cent of copper).

In the area containing the low-grade ore body 12 additional churn-drill holes were put down, aggregating 8,407 feet. This drill work was not undertaken with the idea of increasing the tonnage, but of more clearly defining the limits of the ore body. No revision of the estimate has therefore been made, and the reserves of this grade stand at 28,000,000 tons with an average of 1.06 per cent copper.

In addition to the above, there is the body of mixed oxide and sulphide ore partially developed, estimated to contain 6,000.000 tons averaging about 2 per cent copper.

At the Copper Hill property[1] 12,687 tons of smelting ore, containing an average of 9.64 per cent of copper, and 27,016 tons of concentrating ore, containing 4.52 per cent of copper, were mined and shipped to the Old Dominion smelter and concentrator. Dividends paid since October 31, 1916, amount to $556,500, including $424,000 paid in 1917. The company's report says:

Mining operations were suspended during the year from July 2 until August 18 on account of the strike. * * *

The most important ore developments for the year were on the eighth and tenth levels east of the Budget fault, on the ore which was first discovered in 1915 on the twelfth level and in 1916 on the tenth level. * * *

The ore on the eighth level has been developed for a distance of 300 feet farther east than the end of the tenth level. The average grade of the ore developed on the eighth and tenth levels is considerably higher than that heretofore developed in the mine. It is not, however, as desirable as smelting ore on account of its low content of sulphur and iron and its large amount of silica. * * * A noticeable characteristic of this ore shoot is the occurrence of small rich lenses of ore at intervals along both the foot and hanging walls, separated by siliceous ore of concentrating grade. These shoots do not seem to be regular but change from one wall to the other, it not being unusual to find rich ore on both the foot and hanging walls in the same portion of the vein. * * *

On the twelfth level little was accomplished toward developing new ore on account of the large flow of water coming from east of the Budget fault. * * *

On both the thirteenth and fourteenth levels, near the fault, there is still a considerable tonnage of sulphide ore of smelting grade which has not been extracted on account of the water from the fault. * * *

The fifteenth level had been advanced for about 100 feet at the time of the strike. Work was not resumed on the fifteenth level until the latter part of October, and no ore had been developed on the level at the end of the year. A raise from the fifteenth to the fourteenth encountered ore 35 feet below the fourteenth. Nothing was done on the sixteenth level after work was discontinued on the station.

From the Iron Cap property[2] in 1917 there were shipped 20,989 tons of ore to the El Paso smelter and 10,631 tons of concentrating ore to the Old Dominion mill. The production from both milling and shipping ore was 145,788 ounces of silver and 4,584,000 pounds of copper. According to the company's annual report, the development was as follows:

---

[1] Arizona Commercial Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

[2] Iron Cap Copper Co. Ann. Rept. for year ending Dec. 31, 1917.

> The Williams shaft has been sunk 128 feet to a total depth of 1,083 feet. A station is being cut on the eleventh level. * * *
>
> The Iron Cap shaft has been sunk 130 feet and is now 15 feet below the tenth level. * * * The 900-foot level was opened during the year by crosscutting from the shaft to the vein and drifting east and west on the vein about 700 feet. Stopes have been opened for a distance of 327 feet. The vein has increased in width as well as in the value of the ore over the level above.

At Miami during 1917 the International smelting plant[1] treated 242,936 tons of copper concentrates and 26,839 tons of purchased ores, or a total of 269,775 tons, from which there were produced 138,762,411 pounds of fine copper, 201,859 ounces of silver, and 2,953.64 ounces of gold.

Green Valley district.—The Pittsburg & Tonto property yielded a little sulphide copper ore, which was shipped to Globe in 1917.

Richmond Basin district.—A small quantity of silver ore was shipped to San Francisco and to Deming, N. Mex., from the Jumbo property.

GRAHAM COUNTY.

From 13 producers in the county there were reported 12,574 tons of ore containing gold, silver, copper, and lead, valued at $290,190. Most of this ore, 9,024 tons in quantity, was of milling grade and produced copper concentrate from ores mined in the Bunker Hill district. The Bunker Hill, Aravaipa, Ashpeak, Lone Star, and Stanley Butte districts produced altogether 1,721 tons of smelting ore.

Aravaipa district.—Three producers yielded 1,595 tons of ore, containing $289 in gold, 28,098 ounces of silver, 67,557 pounds of copper, and 1,351,277 pounds of lead, valued in all at $158,095, or an average value per ton of $99.12. The Laurel Canyon Mining Co. operated the Grand Reef property, which is said to have produced ore carrying 41 per cent of lead and 5 to 10 ounces of silver per ton. This, with the production of two other operators, makes the total output an important one.

Bunker Hill district.—The Copper State, New York, California, and Table Mountain properties were the only producers in 1917 and shipped some concentrate and crude ore containing copper. Some lead was contained in the ore shipped from the last-named property.

Lone Star district.—Three producers shipped directly to the smelters 1,588 tons of ore, containing $28 in gold, 663 ounces of silver, 134,403 pounds of copper, and 46,319 pounds of lead, valued in all at $41,249, or an average value per ton of $25.98. The Atlas Copper, Mono, and Ten Strike were the producers.

Stanley Butte district.—The Copper Reef and Friend properties each shipped oxidized copper ore to the Globe and Miami smelters.

---

[1] Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

GREENLEE COUNTY.

Mine production in Greenlee County, Ariz., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1916	19	2,011,882	$50,594	90,759	75,976,831	8,540	$18,801,202
1917	17	1,431,118	52,734	83,458	53,072,330	....	14,610,249
Increase or decrease, 1917	....	−580,764	+2,140	−7,301	−22,904,501	−8,540	−4,190,953

In 1917 there were 17 producers of ore in Greenlee County. The quantity of ore mined was 580,764 tons less than was reported by 18 deep-mine producers in 1916. The ore sold or treated averaged $10.21 a ton in 1917, against $9.35 a ton in 1916. The gold and silver reported as being recovered from the refining of copper bullion amounted to only 8 cents a ton. The concentrating ores aggregated 1,268,783 tons and produced 164,371 tons of concentrates, which contained $42,206 in gold, 65,629 ounces of silver, and 40,087,614 pounds of copper, valued in all at $11,040,203, or an average value per ton of $67.17. The ore smelted was 153,064 tons, all of which was copper ore except 30 tons of siliceous ore. Of the copper ore, 101,527 tons were estimated to be oxidized and 51,507 tons were sulphide. No placer production was reported in 1917.

Ashpeak district.—The Ashpeak mine, placed under option in March to a Nevada company,[1] is mentioned in its annual report as follows:

> The vein, a silver-bearing quartz-filled fissure of unusual persistence, had been developed to a depth of 500 feet. No ore of importance was exposed, but a favorable rock change, accompanied by gradually increasing values, was indicated as taking place with depth. Development work is now being carried on to determine whether these favorable conditions continue until ore in payable quantities will result.

Copper Mountain and Greenlee districts.—The combined production of these two districts is represented in the table giving the production of Greenlee County.

In 1917 the Detroit mine[2] produced 310,743 tons of concentrating ore assaying 2.34 per cent of copper, which yielded 1.62 per cent of fine copper. There were 16,594 tons of smelting ore treated assaying 8.73 per cent of copper, from which was recovered 8.32 per cent of fine copper. From this output and 904 tons of old slag and tailing and 5,022 tons of siliceous copper ore to converters, there was produced altogether 13,202,201 pounds of fine copper. A distribution of the tonnage of ore from the various mines into different classes is taken from the annual report of Phelps Dodge Corporation, as follows:

Mine.	Total.	Second class.	Sulphide.	Oxide.	Quartz.	First class.	Precipitates.
Ryerson	135,670	132,456	615	....	....	2,596	2.4
Yankie	81,304	76,039	904	....	2,924	1,438	.1
Copper Mountain	56,643	53,731	392	2,521	....	....	....
Arizona Central	50,899	50,530	368	....	....	....	....
	324,516	312,756	2,279	2,521	2,924	4,034	2.5

---

[1] Goldfield Consolidated Mines Co. Eleventh Ann. Rept., for year ending Dec. 31, 1917.
[2] Phelps Dodge Corp. Ann. Rept. for year ending Dec. 31, 1917.

A labor strike completely stopped the production of copper for four months and caused a very much reduced output for November and December.

The Arizona Copper Co.'s report[1] for the fiscal year gives the following information:

During the year our production of copper amounted to 42,480,000 pounds, which compared with 34,144,840 pounds for the previous year.

The total ore mined from the company's properties amounted to 1,178,087 tons, as compared with 905,486 tons the previous year, and the yield, as indicated by the smelter returns from ores treated, was 36.6 pounds of copper per ton of ore, which compares with a yield of 36.06 pounds per ton treated during the previous year.

The period under review may be characterized as a period of severe stress from an operating standpoint, on account of the peculiarly difficult labor situation which has existed in this State for some time past. * * *

The daily output of ores from the mines was 4,808 tons, as compared with 4,006 tons the previous year, and represents what may be considered the maximum output which can be conveniently handled with present facilities, all departments operating at full capacity.

The grade of smelting ore treated was 5.714 per cent copper, while the grade of concentrating ore treated was 2.435 per cent copper. * * *

The total ore treated by concentrators during the year was 1,127,054 dry tons.

No. 6 concentrator treated 996,699 dry tons of an average grade of 2.44 per cent copper, containing 0.34 per cent in the oxidized form. A total extraction of 73.02 per cent was made, or an increase of 3 per cent over that of the previous period. * * *

No. 4 concentrator, at Clifton, treated 130,355 dry tons of ore during the period, and the grade of this ore was very low, being only 2.26 per cent, of which 0.36 per cent was in the oxidized form. The average extraction here was 71.33 per cent, or slightly better than that made during the previous year.

Additional flotation cells have been added to this plant, and the old vanners have been removed and are being replaced with Deister tables with the expectation of making a better recovery. * * *

The smelter was operated on a two-furnace basis throughout the year, except when impossible on account of strikes.

The average amount of new material smelted daily was 812 dry tons. * * *

The work of excavating the slag from the old Clifton smelter site has proceeded continuously throughout the year, the total tonnage of this material recovered at the end of September being 20,849 dry tons, assaying 3.82 per cent copper, which has been resmelted, and considerable tonnage still remains.

The Shannon property[2] was operated under many difficulties in 1917, resulting from the labor strike and high prices of materials. The company recently purchased the Yaeger Canyon property in Yavapai County and paid dividends in 1917 amounting to $525,000, most of which were from profits in 1916 and accumulated surplus. The company's report contains additional information as follows:

The company mined and treated during the period of operation 157,000 tons of ore from its own properties and 13,800 tons custom ore, or a total of 171,000 tons, from which was produced 6,138,219 pounds of copper, 1,096.2132 ounces of gold, and 51,771.35 ounces of silver. * * *

Aside from the small production and the large expenses incurred during the year incidental to the five months' shutdown, the other elements that entered into making the cost of producing copper unusually high this year were the lower copper contents of our Metcalf ores and the constant increase in the cost of labor, fuel, and supplies. Wages are to-day 120 per cent higher than they were before the war. Fuel oil, which the company uses in its power plant, advanced from 37½ cents per barrel in 1916 to $1.35 per barrel. Coke, for which we paid $3.75 per ton before the war, is now $8.60 per ton. Lumber advanced from $24 per thousand, the pre-war price, to $34 per thousand. And so on through the list of everything used in the operation of our property.

---

[1] Arizona Copper Co. Ann. Rept. for year ending Sept. 30, 1917.

[2] Shannon Copper Co. Ann. Rept. for year ending Dec. 31, 1917.

It should be pointed out here that the principal ores produced from the Shannon mines are semioxidized, direct-smelting ores and are not susceptible to treatment by concentration. This makes the cost at Shannon higher than at other western mines producing low-grade sulphide ores, susceptible to mechanical concentration, which is a much cheaper process than treating by direct smelting.

For many years it has been expected and assumed that the oxidized ore deposits of the Shannon mines were nearing their end. Lateral developments, however, continued to uncover from time to time additional ores, and enabled us to maintain our normal production of copper. Recently, however, these ores, aside from being more scarce, have also become too low in grade to be smelted at a profit under existing high cost of labor, fuel, and supplies.

It is intended, therefore, to eliminate gradually the mining of these low-grade semioxidized ores and to mine and treat only concentrating ores and such other ores as will show a profit on the present price of copper. * * *

Foreseeing the possibility of the exhaustion of the Metcalf mines, your directors caused the investigation of various mining properties with a view of purchase. * * *

The other mines which were acquired by your company a few years ago, known as the Leonard group, are also showing encouraging developments and offer the possibility of becoming larger and more profitable producers than in the past. There is reason to hope, therefore, that when these two outside mines are brought to a greater state of development their production will offset the loss of production through the exhaustion of the Metcalf mines. Despite the five-month shutdown and the expense it entailed, and despite the distribution of $525,000 in dividends and the investment in connection with the exploration and purchase of the Yaeger Canyon property, your company is free from any floating debts.

MARICOPA COUNTY.

The output of 1,552 tons of ore in 1917, reported by 14 producers, was 17,119 tons less than was reported by 22 producers in 1916. The total average value per ton increased from $3.82 in 1916 to $36.91 in 1917, and the gold and silver value of this ore from $3 to $20.06. The milling ores aggregated 428 tons, producing gold and silver bullion, a decrease from 764 tons in 1916. The higher average value was due to shipments of picked ore (1,124 tons) selected to bear the cost of treatment and transportation to the smelter. The total value of all the ore milled and shipped amounted to $57,282, a decrease of $11,282 from 1916. The reports of 4 placer operators show the recovery of $3,088 in gold and 24 ounces of silver, against an output of $412 in gold and 2 ounces of silver in 1916.

Cave Creek district.—The Mormon Girl property yielded oxidized copper ore, valuable in gold and containing some silver. All this ore was shipped to the Hayden smelter in 1917.

Prosperity district.—The Gun Boat property yielded a small tonnage of lead-sulphide ore, containing gold and silver. This was shipped to San Francisco.

Salt River district.—The Delta property yielded a small quantity of gold ore, containing some silver and copper, shipped to the Douglas smelter.

Sunset district.—The Black Bird property is reported to have yielded gold bullion recovered by the amalgamation process.

Vulture district.—The principal part of the district ore output, consisting of 237 tons of ore, was treated in the milling plant of the Vulture Co. This is the smallest production reported from the district in recent years. Some gold and silver bullion was recovered from the ore milled, and some ore was shipped directly to the smelter.

Wickenburg district.—There were 583 tons of ore produced from various prospects in the district, though some of it may have come from adjoining districts. This ore contained $3,054 in gold, 1,194 ounces of silver, 52,669 pounds of copper, and 31,907 pounds of lead, valued in all at $21,161, or an average value per ton of $36.30. Most of this ore was received in small lots at the Arizona Smelting & Reduction Co.'s sampling and concentrating works, where it was mixed for reshipment or brought up to shipping grade by concentration and shipped to the smelters. The company also purchased ores from properties in Maricopa, Yuma, and Yavapai counties and dealt in ores of rare metals.

MOHAVE COUNTY.

Mine production in Mohave County, Ariz., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	45	207,536	$1,038,814	270,193	1,270,051	5,849,842	17,047,117	$4,216,987
1917	59	275,565	2,463,178	370,094	897,973	6,141,246	17,149,200	5,290,649
Increase or decrease, 1917	....	+68,029	+1,424,364	+99,901	−372,078	+291,404	+102,083	+1,073,662

The total average value per ton of the ore produced by 59 mine operators decreased from $20.32 to $19.20, but the gold and silver value increased from $5.86 to $10.05 per ton. The total gold increased in value from $1,038,814 in 1916 to $2,463,178 in 1917; the silver from $177,787 to $304,958; and the lead from $403,639 to $528,147. The value of the copper decreased from $312,433 in 1916 to $245,147 in 1917; and that of zinc from $2,284,314 to $1,749,219. Most of the ore produced in the county is of milling grade and yields bullion or concentrates. There were 167,518 tons of ore treated by amalgamation or cyanidation, which produced $2,319,024 in gold and 57,477 ounces of silver, with a total value of $2,366,385, or an average value per ton of $14.13. The concentrating ores aggregated 76,397 tons and produced 33,801 tons of concentrates, against 100,363 tons of ore and 34,086 tons of concentrates in 1916. The concentrates in 1917 contained $129,073 in gold, 265,622 ounces of silver, 55,542 pounds of copper, 5,454,404 pounds of lead, and 16,809,871 pounds of zinc, having a total value of $2,546,795, or an average value per ton of $75.35. Crude ore shipped to smelters amounted to 5,395 tons, against 5,400 tons in 1916. In 1917 shipping ore contained $15,081 in gold, 46,995 ounces of silver, 836,431 pounds of copper, 686,842 pounds of lead, and 339,329 pounds of zinc, and had a total value of $375,831, or an average value per ton of $69.66.

Bentley district.—All of the ore produced in the district required hauling a great distance by truck and wagon to the railroad, most of it as far as St. Thomas and Moapa and some of it to Lund, a station in Utah on the Salt Lake Route. The larger part of the production came from the Grand Gulch and Savanic properties. The Copper Mountain mine was also a producer. Altogether there were 2,939 tons of ore produced, containing 1,405 ounces of silver and 813,531 pounds of copper, valued in all at $223,252, or an average value per ton of $75.96.

Cedar Valley district.—There were four producers reporting the production of ore. Various products came from the Diamond Joe, San Francisco, and the Leviathan properties. The last-named property produced sulphide ore containing chalcopyrite and molybdenite, which carries a small amount of gold and silver. The mill on the property makes a sulphide concentrate, which, during 1917, was shipped to Los Angeles.

Indian Secret district.—The White Hills property yielded a small test shipment of silver ore, which went to San Francisco in 1917.

Hackberry district.—Lessees' working on the Old Hackberry mine produced a lead-zinc ore, which was concentrated at Needles, and a crude ore, carrying lead and silver, which was shipped directly to the smelter near San Francisco.

Salt Springs district.—The Arizona & Clipper group was prospected, and a little gold bullion was recovered from ore treated in a neighboring mill. The property is situated 65 miles northeast of Chloride.

San Francisco district.—There were 167,258 tons of ore mined in the district, from which were recovered $2,310,270 in gold and 57,353 ounces of silver, valued in all at $2,357,529, or an average value per ton of $14.10. One small lot of ore containing gold and silver was shipped directly to the smelter, and 499 tons of sweepings were treated at milling plants. The principal production of ore came from the United Eastern and Tom Reed mines, each producing about the same quantity of ore, which was treated by the cyanidation process.

Work at the Gold Road mine[1] was confined entirely to exploration. No stoping was done, and the mill was not operated. Work was continued on the narrow vein of ore of good grade discovered in 1916. A fair tonnage of this ore has been opened up.

The Tom Reed mine[2] yielded at its cyanidation plant gold bullion valued at $620,178.74 from 81,114 tons of ore and $6,432.56 from 770 tons of tailing treated within the fiscal year ending March 31, 1918. During the previous year 46,170 tons of ore were milled, yielding $486,677.98. No dividends were paid during the company's fiscal year. The following paragraphs are from the company's report:

> During the month of April and up to May 26, 1917, the old 20-stamp mill was in commission, which, together with the two tube mills, handled 7,940 tons of ore. * * * On May 26, 1917, the newly installed mill equipment, consisting of the three Allis-Chalmers ball mills, the four new 12 by 40 foot Dorr agitators, and one 12 by 40 foot Dorr thickener, were put in operation, since which time the new plant has treated 73,830 tons of ore and 459 tons of scrapings from the tailings pond, making a total of 74,289 tons treated prior to the close of the fiscal year.
>
> The average value of the ore heads for the year was $7.59 per ton, with an average gross tailings loss per ton of 44.6 cents, to which should be credited the net recovery from the tailings treated, which leaves a net tailings loss of 36.7 cents per ton for the year, or an extraction of 95.14 per cent. * * *

---

[1] United States Smelting, Refining & Mining Co. Twelfth Ann. Rept., for year ending Dec. 31, 1917.

[2] Tom Reed Gold Mines Co. Tenth Ann. Rept., for year ending April 1, 1918.

During the year 81,884 tons of ore were milled at a cost of $2.6261 per ton, including overhead and all indirect charges, as compared with a cost per ton of $2.7556 for the preceding year. Mining costs were $2.6265 per ton; including all overhead charges, compared with $3.1271 for 1916. The total cost per ton for mining and milling, inclusive of administration, taxes, and depreciation, was $5.2526 per ton, a showing of unusual economy in operation, which resulted in lowering the unit costs of the year 1917, which had established a new record for low mining and reduction costs in the district. This may be considered a distinct accomplishment if the rising cost of material and labor is considered. The only deduction that can be gained from these figures is the fact that the percentage of metallic content in the ore mined and treated during the year 1917–1918 was much lower than in any previous year, the average value for the current year being $7.59 per ton as compared with $11.03 for the year previous. Consequently, although aggregate expenses of operations were greater, unit costs were somewhat lower for this year than last.

At the end of 1916 the United Eastern mine[1] and mill were both ready for active work, and regular mining and milling operations began on January 4, 1917. The total production for the year was 84,548 tons of ore, from which were recovered 86,629.411 ounces of gold, valued at $1,790,785.50, and 44,353.17 ounces of silver, valued at $36,885, or a total value of $1,827,670.50, and an average per ton of ore of $21.74. The loss in the tailing was 3,245.454 ounces of gold and 1,256.14 ounces of silver, valued in all at $68,134.82, or an average of 68 cents a ton. Dividends paid in 1917 amounted to $408,900. The company report continued with the following detail:

Stoping is done by the cut and fill method. Square-sets are used on the levels, two sets high, and above them the stope is kept filled with waste rock to within working distance of the backs. The ore is broken down on plank floors. It was at first planned to use a variation of the cut and fill method of stoping, known as the "rill system," but the nature of the ore and walls was such that this proved to be impracticable, so the backs are now kept horizontal and are carried forward by steps.

Development work was done to the extent of 2,066 feet of drifting, crosscutting, and raising, and the No. 2 shaft was sunk an additional depth of 297.5 feet to the total depth of 1,163.5 feet. As a result of the development work, substantial additions were made to the ore reserves above the 665-foot level, and the shaft sinking is in preparation for the development of ore on the lower levels. * * *

At the Big Jim mine, after its acquisition by this company in April, 1917, 854 feet of drifting and crosscutting was done with favorable results, but development work was stopped in August on account of the unusually high cost of labor and supplies. * * *

The mill operates on the continuous counter-current decantation process of cyanide treatment. As it was originally designed, the crushing and grinding department had a capacity of 400 tons per day, and the department for cyanide treatment had a capacity of 200 tons per day. The limit of 200 tons was considerably exceeded after the first two months of operation, and by making some additions and changes, the daily capacity was increased until the monthly average is now close to 270 tons per day. * * *

The ore has proved readily amenable to cyanide treatment. The gold is free, and there are practically no minerals in the ore that interfere with the process. Very fine grinding is necessary on account of the minute subdivision of the gold. Eighty per cent of the ore is ground to pass through a 200-mesh screen. The solution in the agitators is kept at a strength of 2.6 pounds of cyanide per ton of solution, and the consumption of cyanide is 0.722 pound per ton of ore. That the process is well adapted to the ore is proved by the satisfactory rate of extraction of 96.33 per cent, which represents the average for the year.

The cost of mining and milling has been very moderate considering the extraordinarily high prices of labor and materials that have prevailed during the year. The average operating costs were: Mining, $4.181 per ton; milling, $2.159

---

[1] United Eastern Mining Co. Ann. Rept. for year ending Dec. 31, 1917.

per ton; marketing costs, $0.123 per ton; indirect costs, $0.65 per ton; and total operating costs, $7.113 per ton.

These figures include development work and all taxes, except Federal income taxes, but do not include shaft sinking. They will compare favorably with the costs of similar work elsewhere under like conditions.

Wallapai district.—Twenty-nine producers reported 104,362 tons of ore, containing $144,959 in gold, 294,197 ounces of silver, 84,394 pounds of copper, 6,087,742 pounds of lead, and 17,127,596 pounds of recoverable zinc, valued in all at $2,680,978, or an average value per ton of $25.69. Of this ore, the largest part, or 76,250 tons, was milled and produced 33,751 tons of concentrate containing gold, silver, copper, lead, and zinc. This concentrate, with 2,238 tons of ore, was shipped directly to the smelters. There were 25,756 tons of old tailings reconcentrated and 100 tons of oxidized copper ore leached with sulphuric acid and the copper precipitated by electrolysis. This test was made on ore from the Emerald Isle property. The principal producers were the Golconda and Tennessee mines. The former yielded ore from which zinc concentrate containing gold and silver was saved. All of the ore from the Tennessee mine was shipped to Needles for treatment, the resulting zinc concentrate going to Checotah, Okla. According to the report[1] of the company operating the Tennessee mine, the decrease in the price of spelter and lead made the extraction of ore unprofitable and caused the discontinuance of the lease under which the company was operating. Simultaneously the mill for the treatment of this ore at Needles, Cal., was shut down.

The Schuylkill mine adjoins the Tennessee mine on the north, and like many others in the district it is an old mine reopened. The 700-foot level has been reached, and it is reported that sinking will be continued to the 1,000-foot level. The Elkhart, lying north of the Schuylkill, is another old mine of the district. It was unwatered the latter part of 1916 by the American Smelting & Refining Co. for examination. Some mill ore was shipped from the property in 1917, which yielded concentrates containing gold, silver, lead, and a little copper. The Stockton Hill section, lying on the east side of the Cerbat Range and about east of the old town of Cerbat, shared in general activity by the work of the Arizona-Butte property. A 150-ton concentrator equipped with rolls and tables was operated in this section and treated the ore of the Banner and several other mines in 1917. The concentrate and crude ore shipped contained gold, silver, and lead. A lot of lead-zinc concentrate was also shipped.

From the Payroll claim a considerable quantity of lead-zinc ore was shipped to the Needles mill. The Middle Golconda property was also a producer of zinc ore, which was shipped directly to the smelter.

PIMA COUNTY.

Sixty-one operators of deep mines produced 995,909 tons of ore in Pima County in 1917, against 173,985 tons and 62 producers in 1916. The output from deep mines in 1917 included $2,775 in gold, 167,514 ounces of silver, 34,877,443 pounds of copper, 687,019 pounds of lead, and 194,611 pounds of zinc, valued in all at $9,741,282, or an average value per ton of $9.78. The placer output was $4,778 in gold and 120 ounces of silver. The most notable increase was in the output of copper from the low-grade disseminated ores produced in the Ajo district.

---

[1] United States Smelting, Refining & Mining Co. Twelfth Ann. Rept., for year ending Dec. 31, 1917.

Ajo district.—There were 11 ore producers reporting the output of 801,026 tons of ore, from which was recovered $852 in gold, 6,754 ounces of silver, and 20,201,645 pounds of copper, valued in all at $5,521,466, or an average value per ton of $6.89. Of this output, 70,800 tons were shipped directly to the smelter, most of it for converter lining, and the remaining ore was leached in the plant of the New Cornelia Copper Co., which, in 1917, was the principal producer in the district. Crushing of the ore was begun at the New Cornelia[1] plant in April, and on May 1 the first work of spreading ores in the leaching tanks was commenced, and then gradually each part of the plant was put in operation successfully. The first shipment of electrolytic copper was made from Ajo on June 18. The company's report says:

> In addition to the ore mined and treated at the plant 60,561 tons of richer ore was sent to Douglas under an advantageous contract. At first we mined rather lean ores from the original New Cornelia property, but since the absorption of the Ajo Consolidated property we are now shipping from a compact body in that property containing 425,000 tons of ore that according to the drilling and shipments contains better than 4 per cent copper. The total production for the year was 19,482,191 pounds, separated as follows: Electrolytic copper, 12,764,848 pounds; copper in cement copper shipped, 3,316,283 pounds; and copper in ore shipped, 3,401,060 pounds.
>
> In addition to this there is 3,456,584 pounds of recoverable copper locked up in the process. This figure includes starting sheets of which we have a large stock, unfinished cathodes, copper in solution, and cement copper in launders. Of course, a corresponding amount will remain as in process of manufacture as long as the works are operated, but it must be remembered that all this has been partially manufactured during the current year. * * *
>
> While the amount of cement copper produced was about 25 per cent of the total copper resulting from leaching operations and the electrolytic copper produced was about 75 per cent, we are finding out that this proportion of cement copper may be largely decreased. More electrolytic copper will be made in proportion to cement copper, because refined copper from the latter costs about 2 cents a pound more than our electrolytic copper and suffers a deduction of 3 per cent for smelting loss besides.
>
> During the year the New Cornelia Copper Co. absorbed the property of the Ajo Consolidated Copper Co., and the combined properties now have the following ore developed:

	Quantity (short tons).	Copper (per cent).
Oxidized ores	12,800,569	1.568
Sulphides	40,302,457	1.587
Total	53,103,026	1.582
Less ore mined	840,424	1.803
Total	52,262,602	1.579

> Included in the above estimate of oxidized and carbonate ores there is one body containing about 400,000 tons of ore estimated to contain a little over 4 per cent of copper which will be mined and shipped to the Calumet & Arizona smelter at Douglas.

---

[1] New Cornelia Copper Co. Ann. Rept. for year ending Dec. 31, 1917. The early history and present developments are interestingly described by Courtenay De Kalb in the Mining and Scientific Press for Jan. 26, 1918, p. 115, and Feb. 2, 1918, p. 158.

Amole district.—The Mile Wide property yielded sulphide copper ore carrying a little silver, which was shipped to Sasco. This property is opened by an inclined shaft 400 feet deep and has about 2,800 feet of drifts.

Arivaca district.—Some gold and silver bullion was recovered from ore produced in this district in 1917.

Baboquivari district.—The Papago Chief property is equipped with a small mill in which there is one concentrating table. It is reported that there was a small shipment of gold and silver ore from the property in 1917.

Cababi district.—Three properties were credited with the production of small quantities of ore mined and shipped, part of which was gold ore and the rest a copper-lead ore.

Empire district.—Five producers reported the production of 1,528 tons of ore, containing $76 in gold, 9,015 ounces of silver, 1,323 pounds of copper, and 326,799 pounds of lead, valued in all at $35,970, or an average value per ton of $23.54. About half of the ore was shipped directly to the smelter, and the remainder, 779 tons, was milled near Tucson. The principal production of oxidized lead ore of smelting grade was from the Forty-nine mine, the ore being shipped to El Paso, Tex., and Deming, N. Mex. The Total Wreck was also a producer of milling ore. The concentrate, carrying a large percentage of molybdate of lead, was all treated by the Arizona Rare Metals Co. of Tucson.

Helvetia district.—Ten producers reported the production of 18,499 tons of ore, containing $269 in gold, 24,525 ounces of silver, 2,615,613 pounds of copper, and 19,171 pounds of recoverable zinc, valued in all at $736,496, or an average value per ton of $39.81. The Narragansett was the principal producer, shipping oxidized copper ore containing some silver. Numerous operators on the property of the Rosemont Copper Co. shipped, in addition to oxidized copper ore, a small quantity of zinc ore. Other known producers were the Sweet Bye and Bye, Bulldozer, and Pickwick properties.

Old Baldy district.—Two carloads of copper ores were reported to have been shipped from the Gray Jackson property in 1917.

Pima district.—There were 18 producers reporting 45,299 tons of ore, containing $145 in gold, 57,639 ounces of silver, 4,440,864 pounds of copper, 263,872 pounds of lead, and 175,440 pounds of recoverable zinc, valued in all at $1,300,584, or an average value per ton of $28.71. All the ore produced was of shipping grade and came principally from the Glance, Mineral Hill Consolidated, Plumed Knight, San Xavier, Morgan, and Vulcan properties.

Roskruge district.—A small quantity of gold bullion was recovered from ore treated from the Roadside property.

Santa Catalina district.—Copper sulphide ore, carrying some silver, was shipped from the Pontotoc property.

Santa Rosa district.—Oxidized copper ore shipped to the smelters at Douglas was reported from the Aeolian property in 1917. This ore carried about 40 per cent of silica and 7 per cent of iron, besides its copper.

Silver Bell district.—The operation of the smelter at Sasco created considerable activity in the district, and there was an increased tonnage treated from the Imperial mine, as well as from the Oxide and El Tiro properties. The total output of the district aggregated 125,124 tons of ore from 6 producers. The smelting company, besides treating ore from the Imperial and other mines in the district, handled a large quantity of ore from other districts of Arizona. The operator of the smelter was the American Smelting & Refining Co., which is reported to have purchased the mine at Silver Bell and the smelter at Sasco. A large quantity of ore was carried by the Arizona Southern Railroad from Red Rock, where connection is made with the Southern Pacific Railroad.

PINAL COUNTY.

Twenty-six mine operators produced 3,798,731 tons of ore, the principal part of which was from the Ray mines. The ore output was greater by 334,724 tons than the production of 45 operators in 1916. The total average value per ton increased from $6.28 in 1916 to $7.61 in 1917, and the gold and silver in this ore from 15 cents to 19 cents a ton. Nearly all of the ore, or 3,685,395 tons, was of concentrating grade and produced 261,987 tons of concentrate, most of which contained copper, there being only a small quantity of lead concentrate recovered at one property. The ores of smelting grade, shipped directly to smelters, aggregated 108,854 tons and contained 1,552.85 ounces of gold, 216,830 ounces of silver, 11,900,743 pounds of copper, 867,039 pounds of lead, and 11,322 pounds of zinc, valued in all at $3,535,391, or an average value per ton of $32.48. In 1916 the shipments of ore aggregated 53,746 tons, valued at $1,997,613, or an average value per ton of $37.17. At gold and silver mills 2 tons of ore were treated, which produced 91.14 ounces of gold and 135 ounces of silver. No placer bullion was reported in 1917.

Casa Grande district.—Nine producers reported the output of 1,533 tons of ore, containing $145 in gold, 7,493 ounces of silver, 172,326 pounds of copper, 33,014 pounds of lead, and 11,322 pounds of recoverable zinc, valued in all at $57,358, or an average value per ton of $37.42. All of this ore was of smelting grade, the largest part of it being oxidized copper ore from the Lake Shore property treated at Sasco. There were also important shipments from the property of the House Mines Copper Co. Shipments of similar ore came from the Copperosity, Republic & Reward, Vekol, and Security properties.

Mineral Creek or Ray district.—The greater part of the district ore output was from the Ray Consolidated property. There were, however, considerable shipments of crude ore from the Copper Butte mine, the Arizona-Hercules mine, and the Ray Silver Lead property.

In 1917 the Ray Consolidated mine[1] produced 92,207,356 pounds of copper, from which smelter deductions were made, leaving a net production of 88,582,649 pounds. The annual report contains the following paragraphs:

> During the year 3,560,704 tons of ore were mined, leaving the ore reserves of 89,812,522 tons, averaging 2.048 per cent copper. As there was no recalculation of the entire ore body made this year, these results are obtained by difference. At regular periods, however, during the balance of the life of the property, new calculations of the ore reserves will be made whenever develop-

---

[1] Ray Consolidated Copper Co. Ninth Ann. Rept., for year ending Dec. 31, 1917.

ment work indicates that this should be done, in order to state the ore reserves correctly. * * *

The total amount of ore mined from all sources during the year and shipped to the reduction works at Hayden was 3,621,233 tons, an average of 9,921 tons per day, containing 1.681 per cent copper. This is an increase of 7.7 per cent over the year 1916, when the total production was 3,363,466 tons, or an average of 9,190 tons per day. Of the ore received at the mill for 1917, 3,558,080 tons, equivalent to 9,748 tons per day, and averaging 1.635 per cent copper, was milling ore; the remainder, 63,153 tons, averaging 4.28 per cent copper, was sorted or selected ore which was diverted to the smelter for direct smelting.

The mining costs for the year were $1.09, of which $0.0466 per ton was due to coarse crushing and loading, leaving the net mining cost $1.04. The tonnage produced from the No. 3 shaft was not obtained by the regular caving system used at the balance of the property, but was extracted through the use of the square-set system of mining, which is approximately four times as expensive as the regular method. Eliminating this tonnage, the average mining cost was $0.99. These costs are higher than those for the previous year, when the mining cost was 69.12 cents, the difference being largely occasioned by the advance in the cost of supplies, which shows an increase of 32 per cent, and an even greater increase in wages paid, amounting to 51.7 per cent over those prevailing during normal times. During the coming year costs will undoubtedly be still higher, as supplies are becoming more expensive.

The most extensive improvement was the development of an entirely new method in treating the finer or slime products of milling operation. This department is now giving final treatment to approximately 75 per cent of the total tonnage. Work has also been started on the installation of additional fine grinding machinery which will further tend to improve metallurgical results, as particles of mineral now remaining encased in the waste portions of the ore will be liberated and made amenable to recovery. * * *

The total ore milled for the year was 3,560,900 dry tons, corresponding to a daily average of 9,756 tons, as compared with 9,105 tons during 1916. The total tonnage of ore milled since the beginning of operations and to the end of 1917 was 16,782,600 tons, averaging 1.678 per cent copper. The average grade of the ore milled for 1917 was 1.635 per cent copper; the average recovery for the year 74.53 per cent of the entire copper content, equivalent to 24.37 pounds of copper per ton.

The concentrate production for the year was 229,197 tons containing an average of 18.935 per cent copper. * * *

The recovery of copper occurring in the form of sulphides was 83.32 per cent, while that existing as oxides and carbonates, which are not readily amenable to concentration, yielded only 33.48 per cent. Experiments are now being conducted, with encouraging results, with a view to improving oxide and carbonate recoveries.

The cost of milling for the year was 82.86 cents per ton, as compared with 55.35 cents for the last year; the same conditions affecting the increased cost at the mine were apparent at the mill, except that there was a greater proportionate increase in the cost of supplies, which at the mill amounted to 51 per cent in excess of that applying in normal periods.

The gross production of copper from all sources was 92,207,356 pounds. This represents an increase of 18 per cent over the gross production of 77,856,713 pounds for 1916. There was produced from the ores delivered without concentrating direct to the smelter a total of 5,409,770 pounds. * * *

The average cost per pound of net copper produced from milling ores, after making allowances for smelting and refining deductions and crediting dividends from the Ray & Gila Valley Railroad and other miscellaneous income as a reduction of operating costs, was 12.141 cents per pound. The combined cost per pound of net copper produced from milling ore and direct shipping ore for the year was 12.229 cents, as compared with 10.267 cents per pound for the previous year. These costs include all operating and general charges, as well as 12.5 cents per ton of ore milled which is applied to the redemption of mine-development costs.

The Ray Hercules property,[1] consisting of 207 acres, is surrounded by the holdings of the Ray Consolidated Co. In 1917, during the construction of the 1,500-ton concentration mill, there was shipped to the smelters considerable copper ore. As to the quantity of developed ore, the company says in its annual report:

---

[1] Ray Hercules Copper Co. Rept. from beginning of operations to Oct. 31, 1917.

> On 13.37 acres of the southwestern portion of the company's ground there was, when the original report was made, estimated to be developed and partially developed 3,428,774 tons of ore having an average assay value of 2.36 per cent copper. This ore was estimated as a result of 16,137 feet of drilling, which had been done prior to September, 1915. Between September, 1915, and February, 1917, 25,864 feet of additional drilling was done. As a result of this drilling and the original drilling, amounting to a total of 42,001 feet, the area is estimated to contain 9,500,000 tons of developed ore having an average assay value of 1.77 per cent copper. Only straight sulphide ore enters into this estimate, and no ore has been taken into consideration beyond the exterior boundaries of lines connecting the drill holes. Nor has any ore been included in my estimate where the drill holes are more than 200 feet apart. The main haulage drift connecting No. 1 shaft and No. 2 shaft and the laterals now being driven therefrom are under the ore body thus far developed by drilling. In the progress of this work more ore is being encountered showing a higher assay value than the average assay value of the ore developed by the drilling.

Old Hat district.—At the Mammoth-Collins mine a 200-ton concentration mill was operated on lead ore, resulting in a concentrate containing wulfenite with some gold. Quite a quantity of tailing was also treated by amalgamation. This property has a vertical shaft on the Mammoth 720 feet deep and an incline shaft 800 feet deep on the Collins. The 200-ton ball mill and concentrating plant was enlarged by the addition of a flotation unit in 1917. The Pearl and the Sunset properties were also producers of oxidized copper and lead ore.

Pioneer district.—Three producers reported production in 1917, the largest one being the Magma mine. The output aggregated 110,572 tons of ore, the larger part of which, 93,975 tons, was milled and produced 32,285 tons of copper concentrate carrying gold and silver. There were also 16,597 tons of crude ore containing copper, gold, and silver, shipped directly to the smelters. The total value of the district production was $3,468,030, or an average value per ton of $31.36.

At the Magma mine[1] 107,529 tons of ore were mined in 1917. This included 13,554 tons of hand-sorted crude copper sulphide ore shipped directly to the smelter, averaging 14.76 per cent of copper and 15.29 ounces of silver and 0.10 ounce of gold to the ton, and 93,975 tons of mill ore averaging 4.02 per cent of copper, 4.38 ounces of silver, and 0.05 ounce of gold. From this mill ore, 16,092 tons of concentrate were produced, containing an average of 10.64 per cent of copper, 11.15 ounces of silver, and 0.14 ounce of gold. The net production from all products, after deducting concentrating, smelting, and refining losses, was 10,148,632 pounds of copper, 537,994.84 ounces of silver, and 5,978.70 ounces of gold. The Magma is opened by a vertical shaft 1,800 feet deep and has a 300-ton mill using gravity concentration followed by flotation. Paragraphs taken from the company's annual report follow:

> The net cost of producing copper, including depreciation and all other charges and deducting the revenue from silver and gold, was 16.01 cents per pound and the average selling price was 26.423 cents per pound. The corresponding costs and average selling price for the preceding year were 11.77 cents and 25.433 cents respectively. * * *

---

[1] Magma Copper Co. Ann. Rept. for year ending Dec. 31, 1917.

During 1917 the No. 2 shaft was sunk from 34 feet below the 1,500 level to 38 feet below the 1,800 level. A station was cut on the 1,600 level, and the main copper ore shoot was partially developed on this level by four crosscuts located an average distance of 60 feet apart. These crosscuts show the vein averages 14.7 feet in width and assays 9.36 per cent copper, 3.82 ounces silver, and 0.03 ounce gold.

During the year diamond-drill holes 15 and 16 were put down from a point in the main crosscut on the 1,500-foot level about 180 feet south of the vein. Drill hole 15 was put down on an angle 60° from the horizontal and pointed due north. This hole passed through the vein at elevations corresponding to the 1,700 and 1,750 foot levels, where commercial ore was indicated.

Drill hole 16 was put down vertically from the same location as 15. It encountered the vein at elevations corresponding to the 2,200 and 2,250 foot levels. As this hole was a deep one, and considerable trouble was experienced due to caving, it had to be abandoned before complete information was secured. Core samples showed copper values in the form of chalcopyrite.

Riverside district.—Three producers reported 132 tons of ore, valued at $4,171, or an average value per ton of $31.60, most of which represents the copper content. The producers were the Prosperity, Sultana, and Troy-Arizona.

Saddle Mountain district.—The Little Treasure property yielded a small quantity of silver ore, which was shipped directly to the smelter.

SANTA CRUZ COUNTY.

Twenty-six producers reported 64,879 tons of ore in 1917, or 34,492 tons more than was reported by 34 producers in 1916. The total value of this ore, containing gold, silver, copper, lead, and zinc, was $1,661,698 in 1917, against $854,605 in 1916. In 1917 the ore sold or treated contained $5,203 in gold, 218,783 ounces of silver, 4,101,176 pounds of copper, 1,839,390 pounds of lead, and 1,945,189 pounds of zinc, valued in all at $1,661,698, or an average value per ton of $25.61. Ore of shipping grade amounted to 41,671 tons and contained most of the copper and some of the lead. The ores produced were classified as copper ore, 47,708 tons; copper-zinc ore, 5,057 tons; lead ore, 3,843 tons; zinc ore, 4,027 tons; lead-zinc ore, 3,240 tons; copper-lead ore, 876 tons; and siliceous ore, 128 tons.

Harshaw district.—Six producers reported 1,314 tons of ore containing $157 in gold, 17,867 ounces of silver, 9,659 pounds of copper, and 426,932 pounds of lead, valued in all at $54,232, or an average value per ton of $41.27. All this ore was of shipping grade, forwarded directly to the smelters. The Flux mine was the principal producer of oxidized lead ore, and smaller quantities were shipped from the Horseshoe, Sunnyside, and World's Fair properties.

Nogales district.—A small production of ore was reported from the Arizona-European property. This was shipped directly to the smelter and contained copper, silver, and gold.

Oro Blanco district.—The most important producer was the Montana property, which was under lease to the Goldfield Consolidated Co. of Nevada. During its investigation considerable lead-zinc ore was produced, which was concentrated in a mill erected especially for its treatment. The property was closed and the lease given up in February, 1918. The operating company[1] reports as follows:

During February an option was taken on the property, and at that time something in excess of 30,000 tons of ore assaying 12 per cent zinc, 6 per cent lead, and 6 ounces silver were considered developed and a small concentrating mill was being erected. It was realized the ore developed was not sufficient to warrant the construction of a mill, but owing to the chance for profit on account of the then high price of base metals and the opportunity that would be afforded for fully determining proper working methods in case the subsequent mine developments should expose additional ore bodies, the mill with accessory construction was completed and is now in operation. The mine development being carried on shows the vein weakening with depth and, while not yet conclusive, indicates future ore reserves will not be of sufficient value to warrant its purchase. At the present time it is apparent the profits from mill operation will not be sufficient to return the amount spent in construction and mine development and a material loss will be incurred.

---

[1] Goldfield Consolidated Mines Co. Eleventh Ann. Rept., for year ending Dec. 31, 1917.

Palmetto district.—The largest part of 20,311 tons of ore produced in the Palmetto district by 3 operators was from the Three R property, which yielded copper sulphide ore shipped directly to the smelter.

Patagonia district.—Four operators reported a production of 38,563 tons of ore, containing $21 in gold, 173,429 ounces of silver, 3,059,619 pounds of copper, 626,099 pounds of lead, and 1,622,843 pounds of recoverable zinc, valued in all at $1,197,576, or an average value per ton of $31.06. The greater part of the ore, 33,506 tons, was shipped directly to the smelters, and 3,154 tons were milled at concentration plants, yielding 426 tons of copper concentrates and 524 tons of copper-zinc concentrates. The largest producer was the Duquesne property.

Tyndall district.—Five operators reported 989 tons of ore containing $744 in gold, 4,525 ounces of silver, 25,770 pounds of copper, and 225,925 pounds of lead, valued in all at $30,938, or an average value per ton of $31.28. There were 257 tons of ore shipped directly to the smelters and 732 tons were milled, producing 183 tons of lead concentrate, carrying principally silver. A large part of the output came from the Wandering Jew property and consisted of concentrating ore containing lead, silver, and a little copper. The other producers were the Burro, Royal Blue, and Santa Cruz.

Wrightson district.—The American Boy, yielding an oxidized copper ore, was the only producer from which a report was received in 1917.

YAVAPAI COUNTY.

Mine production in Yavapai County, Ariz., in 1916 and 1917.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Recoverable zinc content.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1916	95	967,558	$1,035,351	1,735,302	109,525,718	265,023	583,741	$29,217,015
1917	88	1,176,644	1,023,464	2,207,583	159,612,146	686,874	950,762	46,572,677
Increase or decrease, 1917	......	+209,086	−11,887	+472,281	+50,086,428	+421,851	+367,021	+17,355,662

[a] Includes placer production.

Seventy-five deep mines and 13 placers reported a total metal output valued at $46,572,677 in 1917, against $29,217,015 in 1916, when 95 operators of deep mines and placers reported. The total average value per ton of the ore increased from $30.19 in 1916 to $39.58 in 1917, and the gold and silver value in this ore from $2.25 to $2.41. Of the total value of the metals reported, $1,023,464 was for gold, $1,819,048 was for silver, $43,574,116 for copper, $59,071 for lead, and $96,978 for zinc. Compared with that of 1916 the output of each metal shows a substantial increase, with the exception of gold, which was $11,887 less. Ores of smelting grade shipped to various smelters aggregated 1,008,307 tons. Most of this shipment was first-class copper ore (980,644 tons in quantity), of which much the larger part was sulphide ore (954,433 tons) and the remainder was oxidized copper ore (26,211 tons). The total value of the smelting ores was $43,518,241, or an average value per ton of $43.16. There were produced 47,363 tons of dry or siliceous ore, mostly gold ore, the larger part of which was treated at gold and silver mills. Concentrates, amounting to 39,996 tons, derived from 143,811 tons of ore, were smelted and contained $155,463 in gold, 163,957 ounces of silver, 8,657,025 pounds of copper, 28,465 pounds of lead, and 528,360 pounds of zinc, valued in all at $2,710,273, or an average value per ton of $67.76. The placer output amounted to $3,762 in gold and 22 ounces of silver, as against a production of $3,580 in gold and 44 ounces of silver in 1916.

At the concentrating mill and smelter of the Consolidated Arizona Smelting Co., situated at Humboldt, about 1,800,000 pounds of copper is produced monthly from the treatment of about 800 tons of ore daily. Approximately half of the copper production in 1917 was from the ores of the company's mines, the Blue Bell and De Soto, and the remainder from custom material. The concentrator has a capacity of 500 tons of ore per day and treats exclusively the more siliceous ore from the Blue Bell and De Soto mines. No custom ore is milled, and the oxidized domestic ore and basic domestic ore are likewise sent direct to the furnaces. The De Soto ore is all very siliceous, containing 65 to 75 per cent insoluble matter, and is sent to the concentrator, but much of the Blue Bell ore is very basic, and it is more profitable to smelt the ore directly when the percentage of insoluble matter runs below 50 per cent, particularly as the precious-metal content is greater in the more basic ore, and the recovery of it is better in direct smelting than in concentration followed by smelting.[1]

Agua Fria district.—Three producers reported 39,853 tons of ore, nearly all of which was of milling grade, producing copper concentrate carrying silver and a little gold. In addition to the 5,875 tons of concentrate recovered from the milling ore, there were 1,142 tons of ore, containing copper, shipped directly to the smelters. The Binghampton was the largest producer of milling ore, which was treated in its flotation mill, which has recently been increased to a capacity of 250 tons of ore daily. The Copper Queen property, situated near by, also had treated at this mill some of the ore taken out during development work. The Binghampton property is opened by a 1,000-foot adit and a 600-foot shaft, with about 4,000 feet of workings. The ore is chalcopyrite with some iron pyrite and tetrahedrite disseminated in the Yavapai schist. 9 recent article,[2] describing the new flotation mill and the mine, states that the ore stopes are 20 feet wide and from 100 to 200 feet long. One-fifth of the output of the mine is coming from the 600-foot level from new development work.

---

[1] Milnes, P. R., Concentration and smelting at Humboldt, Ariz.: Min. American, Apr. 15, 1918, pp. 3-5.

[2] Min. and Sci. Press, Aug. 4, 1917, p. 174.

Big Bug district.—The reports of 18 operators gave a production of 109,736 tons of ore, containing $146,400 in gold, 191,870 ounces of silver, 6,774,730 pounds of copper, and 256,194 pounds of lead, valued in all at $2,176,035, or an average value per ton of $19.83. The greater part, or 61,355 tons, was milled with a recovery of 19,557 tons of concentrates, containing 3,465.58 ounces of gold, 80,630 ounces of silver, and 3,739,510 pounds of copper. The ore treated in gold and silver mills aggregated 606 tons and yielded bullion containing 380.50 ounces of gold and 465 ounces of silver. Some of this ore was reported to have produced concentrate, which is included in the figures above. The Blue Bell mine was the largest producer of ores of milling and smelting grade, containing copper, silver, and a little gold. All of the ore from this mine was hauled by railroad from Mayer to Humboldt, where the more basic ore and oxidized ore are smelted and the remainder reduced to concentrate, which is smelted. The Blue Bell ore deposit is the result of replacement in schist by chalcopyrite and pyrite, accompanied by secondary silicification. Six ore bodies have persisted with practically the same dimensions on each level from the surface to the deepest workings at 1,200 feet. These ore bodies range in length from 100 to 400 feet and in width from 5 to 25 feet. Two systems of mining are in use—" cut and fill " and overhead stoping on ore or " shrinkage stoping." The latter method predominates and the former is employed only where the stope walls are bad, by reason of severe faulting. The ore is hoisted to the surface in skips through a 3-compartment shaft and dumped into bins, from which it is drawn for the buckets of the aerial tramway, to be carried 3 miles to the railroad. There it is loaded in 40-ton cars for the 12-mile haul to Humboldt over the Crown King branch of the Santa Fe system. The Blue Bell mine's present production is 10,000 tons of ore a month, and the mining cost, including development, is $2.75 to $3 per ton f. o. b. cars Bluebell siding.[1]

For a short time the Big Ledge Copper Co., operating the Henrietta and Butternut mines, smelted its ores in the furnaces situated at Mayer, owned by the Great Western Smelting Co. This plant was closed down for an indefinite period after a short operation in 1917. Lead ore was produced from the Arizona National property, and several small shipments were made from prospects in the district. Some gold bullion and concentrate were recovered from ores mined from the Union property, operated by a new company in 1917.

Black Canyon district.—Two producers reported ore containing gold, silver, copper, and lead valued at $420.

Black Hills district.—A small quantity of ore, containing copper and a little silver, came from the cleaning up of the old works of the Yaeger Canyon property, recently taken under control by the Shannon Copper Co., of Clifton. During the first part of 1918 considerable development work was being done, and the mine will probably produce within that year.

---

[1] Milnes, P. R., Concentration and smelting at Humboldt, Ariz.: Min. American, Apr. 15, 1918.

Black Rock district.—A small quantity of ore, mined from two properties in the district, was reported to have been shipped to the sampling works at Wickenburg, where it was sold for its copper and silver content.

Castle Creek district.—Some ore was shipped to the Wickenburg sampler from the Empress Copper property, the only producer in the district.

Copper Basin district.—The most important operations were carried on at the Copper Basin and Senator properties. All of the ore contains copper and is of shipping grade. The mines are operated by the Phelps-Dodge Corporation,[1] whose annual report gives details as follows:

> There were shipped from the Copper Basin mine 17,299 dry tons of ore containing 934,781 pounds of copper, yielding us $166,090. Of the above tonnage, 762 tons, containing 42,286 pounds of copper, were shipped during the month of December, 1916, and settled for in January, 1917, returning $10,207.57. Also there are approximately 2,700 tons of ore in transit to the smelter unsettled for, which were shipped during the month of December, 1917, and which are not included in the above tonnage for the year. Of the 17,299 tons of ore shipped, 11,658 tons went to the United Verde Copper Co. smelter at Jerome, 4,253 tons to the Copper Queen smelter at Douglas, and 1,388 tons to the Consolidated Arizona smelter at Humboldt, Ariz.
>
> Development and prospecting work totaled 1,250 feet, and ore reserves in sight at the end of the year compare favorably with those of the beginning of the period.
>
> On the Senator group there was driven about 600 feet of new openings, and 800 feet of the Snoozer tunnel was cleaned out and repaired, preparatory to mining the known ore body in the Snoozer vein. Only one carload of ore was shipped during the year, containing 35 tons, the values being largely in gold and silver.

Eureka district.—The development of the Copper King mine and the building of a road connecting this property with the railroad 29 miles distant were carried on during 1917. During this time shipments of zinc sulphide ore were made to a smelter in Arkansas. Work at the surface exposed an important deposit of low-grade oxidized copper and zinc ores, which led to prospecting the deposit in the hope of finding a copper ore body, but instead a very large zinc deposit was opened to a depth of about 200 feet by an incline shaft. The oxidized zinc ore was replaced by sulphides 50 feet from the surface.

Hassayampa district.—Eleven producers reported the output of ore and 2 placer operators reported bullion in 1917. From the deep mines 2,294 tons of ore were produced, of which 614 tons were shipped directly to the smelters, yielding principally lead, a little copper, gold, and silver. At the milling plants 1,680 tons of ore were treated, yielding gold and silver bullion and a small tonnage of lead concentrate. The total output of the district, including that of the placers, amounted to $10,094 in gold, 13,873 ounces of silver, 12,786 pounds of copper, and 163,780 pounds of lead, valued in all at $39,101. The Big Pine, Davis, Crook, Surprise, and Holden properties were the largest producers.

Humbug district.—Production was reported from two properties, the Golden Central and the Marietta, each of which shipped ore containing copper.

---

[1] Phelps-Dodge Corporation Ann. Rept. for year ending Dec. 31, 1917.

Peck district.—Low-grade copper ore mined from the De Soto property and shipped to Humboldt for concentration and smelting formed the principal part of the district output. There was also a small shipment of lead ore from the Swastika property.

The ore deposit of the De Soto mine is due to a replacement in schist by chalcopyrite and pyrite, accompanied by secondary silicification. There are six ore bodies which have persisted with practically the same dimensions from the surface to the deepest workings. The mine is worked through the 2,000-foot adit, which corresponds to the 600-foot level of the mine. Five levels have been opened above the adit and two below it. The mine's production of 150 tons per day is hauled by mules from ore pockets on the adit level to bins on the upper terminal of the aerial tram, a distance of 2,300 feet. The tram line is 4,000 feet long and operates by gravity, there being a difference in elevation of 1,000 feet between the two terminals. The De Soto ore bodies range in length from 50 to 120 feet and in width from 5 to 40 feet. The walls stand firmly, and "shrinkage" stoping is the only method employed. The mining cost,[1] including development, sorting, and tramming, is $2.55 per ton, and freight to Humboldt (25 miles distant) is 70 cents, making the ore cost $3.25 per ton f. o. b. Humboldt.

Pine Grove district.—Ore produced from the Wildflower mine and tailings from the old Crown King mine were treated in the Bradshaw reduction works, a concentration plant which was reconstructed with modern equipment and first operated in 1916.

Silver Mountain district.—The Rose Mary group yielded some bullion from ores treated in a neighboring stamp mill, and a small parcel of very rich gold ore was shipped to the smelter.

Tiger district.—The old mill of the Tiger Gold mine was put in operation by the Bradshaw Reduction Co. and was used in re-treating mill tailings from the former Tiger operations. The Cougar and Nelson properties also produced.

Turkey Creek district.—Four producers in 1917 reported 46 tons of ore, which yielded gold, silver, copper, and a little lead, valued at $1,878.

Verde district.—In 1917 six producers reported the output of 949,094 tons of ore, containing $753,314 in gold, 1,884,673 ounces of silver, 145,983,703 pounds of copper, and 205,817 pounds of lead, valued in all at $42,177,535, or an average value per ton of $44.44. All of the ore produced, with the exception of 15,881 tons, which was milled and produced gold and silver bullion, was of smelting grade and was treated at the smelters at Clarkdale, Douglas, Globe, and Humboldt. The producers were the Copper Chief, Dundee, Jerome Verde, United Verde, and United Verde Extension.

Copper sulphide ore shipped to custom works from the United Verde Extension mine[2] aggregated 115,064 dry tons, containing 63,242,784 pounds of copper, 1,656 ounces of gold, and 332,536 ounces of silver. These figures represent 95 per cent of the metallic content. The construction of a smelter was commenced during 1917. An adit connecting the 1,300-foot level of the mine has been completed for

---

[1] Milnes, P. R., Concentration and smelting at Humboldt, Ariz.: Min. Am., Apr. 15, 1918.

[2] United Verde Extension Mining Co. Directors' report for year ending Dec. 31, 1917. The story of the United Verde Extension mine and the district is interestingly written by T. A. Rickard (Min. and Sci. Press, Jan. 5, 1918, p. 9).

4,133 feet. A standard-gage railroad 3.2 miles long was completed between the smelter site and the portal of the adit.

Important interests have been prospecting ground adjoining the larger producers, but so far without disclosing any large ore body. Some of these developments are mentioned in a recent article[1] as follows:

> Dundee was closed down pending completion of arrangement by which it will use the new Verde Extension traffic tunnel to gain entrance and make a raise from around the 900-foot level to the shaft it has been sinking. Costs of pumping and hoisting will be dispensed with under this plan. Jerome Victor Extension is expecting to recover the 1,200-foot level from the water and resume development there at an early date. The 1,200-foot has been opened slightly; the showing there is promising for the small extent that it has been possible to follow it. Water increases, pump troubles, and machinery breakdowns have interfered at several times. The Verde Extension new blower has greatly improved conditions underground. The fire area has about been disposed of. Progress with the smelter of this company is going on well. The Verde Combination ore find on the 600-foot is near the Gadsden line and is encouraging, although more depth is considered requisite to establish individual value for the strike. The Calumet Jerome is in the same situation, requiring more depth to enable deductions of value. The Del Monte closing-down is apparently for an indefinite period, although additional equipment was received and in course of installation when the closing order came, while a year's stock of general supplies is on hand at the camp and there is an abundant sum of money in the treasury for another year's work. Labor is plentiful in the district, a surplus having been on hand for some time. The demand for an increase of $1 per day both above and below ground will probably be adjusted by Administrator Meyers. The I. W. W. disturbing elements are held to be responsible for the demands. Costs of living in the district are asserted at this time to be no higher than when the present wage scale was agreed upon in June. The administrator is now investigating the costs of living, upon alleged increase in which the demand for higher pay is based. The present wage is $5.15 per day.

Walker district.—Including the production of four deep mines and six placers, the output of the district aggregated $7,723. The ore produced, 132 tons, containing principally gold and silver with a little copper, was shipped directly to the smelters. The placers alone yielded $2,412 in gold and 15 ounces of silver, against a production in 1916 of $1,366 in gold and 9 ounces of silver.

Walnut Grove district.—The McMahon group reported the shipments of some oxidized copper ore containing gold, which was shipped to the Humboldt smelter.

Weaver district.—The Monica property was the principal producer of ore in 1917 and treated about 3,500 tons in its amalgamation and cyanide mill. The output of this property combined with the production reported by three placers aggregated $13,375 in gold and silver.

YUMA COUNTY.

Fifty-two deep-mine operators in Yuma County in 1917 reported the output of 47,233 tons of ore, which was 7,626 tons less than was reported by 45 producers in 1916. The total average value per ton of this ore increased from $21.58 in 1916 to $21.95 in 1917, but the gold and silver value decreased from $1.25 to 90 cents. The total value of the gold, silver, copper, and lead produced in the county was $1,042,233, as against an output valued at $1,190,362 in 1916. The placer production amounted to $5,586 in gold and 61 ounces of silver, against a recovery of $6,249 in gold and 61 ounces of silver in 1916. Ore of shipping grade aggregated 43,565 tons, containing 1,775.48 ounces of gold, 4,550 ounces of silver, 3,577,617 pounds of copper, and 54,752 pounds of lead. At gold and silver mills there were 29 tons of ore treated, which produced 23.15 ounces of gold and 14 ounces of silver.

---

[1] Min. and Sci. Press, p. 135.

Castle Dome district.—Eight deep mines and three placers reported the production of ore and bullion valued at $21,955, of which $20,133 was from 3,688 tons of ore containing gold, silver, and lead and $1,822 represented the placer production. The Hull mine was the principal producer, and smaller yields were made by the Big Eye, Lady Edith, Ophir, Sonora, and Silver Dollar properties.

Cienega district.—Four deep-mine producers reported 1,783 tons of ore of shipping grade containing $11,699 in gold, 1,297 ounces of silver, 307,592 pounds of copper, and 288 pounds of lead, valued in all at $96,766, or an average value per ton of $54.27. The Empire-Arizona was the largest shipper of oxidized copper ore. This property is opened by a 300-foot shaft on the Carnation claim and by a 240-foot two-compartment shaft on the Eagle's Nest claim. These claims are said to show three large veins occurring at the contact of porphyry with limestone and schist. Outcrops of iron oxide carry copper. Several shipments were made from the Billy Mack mine, which was sold to the Illinois Arizona Copper Co. in September. A carload of oxidized copper ore was also shipped from the Nellie property, and various prospects produced ore which was shipped to the sampling works at Wickenburg.

Ellsworth district.—Seventeen deep-mine producers and 2 placers reported an output valued at $85,600. There were 925 tons of ore produced in the district containing $12,517 in gold, 304 ounces of silver, and 259,653 pounds of copper, with an average value per ton of $90.44. The placer yield was $1,919 in gold and 34 ounces of silver. The Critic property was the principal producer, yielding a sulphide copper ore, which was shipped directly to the smelter. There were smaller productions from the Black Reef, Copper Bell, Jerome Wenden, Bullard, Cracker Jack, True Blue, Vindicator, Wenden Copper, and Verde properties.

Kofa district.—One small lot of gold ore was shipped from the district in 1917, probably from one of the old mines.

Planet district.—The output of five deep mines aggregated 40,196 tons of smelting ore, containing $710 in gold, 612 ounces of silver, 2,974,923 pounds of copper, and 779 pounds of lead, valued in all at $813,434, or an average value per ton of $20.24. The principal part of the ore came from the Swansea lease on the Clara copper property at Swansea and was shipped to Humboldt and Sasco. The New Planet mine was also a producer of copper sulphide ore. This property is opened by a vertical shaft 668 feet deep.

Plomosa district.—The output of 11 deep mines and 5 placers in 1917 was valued at $22,522. There were 635 tons of ore produced, containing $11,232 in gold, 534 ounces of silver, and 35,449 pounds of copper and having a total average value per ton of $33.62. The placer output amounted to $1,162 in gold and 12 ounces of silver. The Dutchman was the largest producer, yielding gold ore of shipping grade. There was also some ore shipped from the Desert, Excelsior, Gold Hills, Little Butte, and Cosmos properties.

REDUCTION PLANTS IN ARIZONA.

A list of reduction plants in Arizona was published in Mineral Resources for 1911 (Part I, pp. 427–430). The following list has been revised from that list to the extent of adding the names of new plants and their equipment and of noting changes in the equipment of old mills that now use modern methods. The names of some plants that appeared in the former list have been omitted, as they are reported to be partly or entirely dismantled:

Reduction mills in Arizona in 1917.

[A, active; B, idle; C, under construction.]

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Cochise County:				*Short tons.*
King Copper Co. (C).	California	Concentration	In course of construction	125
Paradise (custom) (A).	do	do	1 crusher, rolls, 1 Huntington mill, 1 classifier, 2 Deister tables.	75
Middlemarch (A).	Cochise	Flotation	Telsmith gyratory crusher, ball mill 6 by 6, Akins classifier, flotation machines.	100
Grand Central (for tailings). (C).	do	Roasting and amalgamation.	Roaster and pans	100
Huachuca (B)	Hartford	Concentration	Crusher, tables	6
Reef (A)	Huachuca	do	Blake crusher, rolls, Allen cone classifiers, 1 Deister and 1 Wilfley table.	70
Tombstone (A)	Tombstone	Concentration, flotation, and cyanidation.	2 Blake crushers, 40 stamps, rolls, 1 tube mill, 2 Dorr classifiers, 12 Wilfley tables, K. & K. flotation machine (experimental), 5 Parral tanks, 2 percolation tanks, 1 Oliver filter.	300
Commonwealth (A).	Turquoise	Cyanidation	40 stamps, 3 tube mills, Dorr classifier, 2 Pachuca tanks, 7 agitation tanks, 4 Oliver filters (partly dismantled in 1917).	300
Copper Queen (A)	Warren	Concentration and flotation.	Telsmith No. 5 crusher, rolls, Hardinge mill, 2 drag and 1 hydraulic classifier, 2 Senn pan motion vanners, 3 Butchart tables, flotation machines.	100
Shattuck-Arizona (C).	do	Gravity concentration, sulphidizing, and flotation.	1 gyratory crusher, Traylor rolls, 2 Marcy mills, 1 tube mill, 5 Allen cone classifiers, 5 coarse and 3 fine Butchart tables, K. & K. and Park flotation machines.	400
Coconino County:				
Bridal Veil (A)	Cataract Canyon.	Concentration	1 set of rolls (9 by 12 inches), jigs.	10
Gila County:				
Dripping Springs (A).	Dripping Springs.	Amalgamation and concentration.	Gardner grinder, jigs	5
Inspiration (A)[a]	Globe	Flotation followed by gravity concentration.	Crushers (at mine), 40 Marcy ball mills, 40 Dorr and 19 drag classifiers, 220 double-deck Deister tables, pneumatic flotation, machines 8 Oliver filters.	18,000

---

[a] Gahl, Rudolf, History of the flotation process at Inspiration: Am. Inst. Mech. Eng. Trans., vol. 55, pp. 576–647, 1917.

Reduction mills in Arizona in 1917—Continued.

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Gila County—Continued.				*Short tons.*
Miami (A)	Globe	Concentration and flotation.	2 gyratory crushers, 17 Hardinge mills, 9 Dorr, 24 Deister and 28 Richards classifiers, 132 Deister slime and 40 Deister sand tables, pneumatic flotation machines, 3 Oliver filters.	6,000
Old Dominion (A)	do	Concentration and flotation (two mills).	2 Traylor rolls, 1 Marathon and 5 Hardinge tube mills, 18 Deister classifiers, 18 Deister tables, 4 Senn vanners, 2 Overstrom tables, flotation machines, 2 Oliver filters.	400 (old mill), 800 (new mill).
Yo Tambien (Pinto Creek) (B).	do	Concentration	2 jaw crushers, 3 Allis Chalmers rolls, 3 classifiers, 1 Hancock jig, 2 Standard and 2 Wilfley tables.	100
Kellner (Yellow Metal) (B).	Lost Gulch	Concentration and cyanidation.	Gates crusher, 10 stamps, 2 Wilfley tables, 2 vanners, tanks.	20
Ray Consolidated (A).	At Hayden	Concentration	16 Garfield rolls, 24 6-foot Chilean mills, 89 Richards Janney classifiers, 550 Isbell vanners, Harz jigs, 100 Wilfley tables, 176 special Garfield tables.	10,000
Graham County:				
Copper Glance (A).	Bunker Hill	Concentration and flotation.	Blake crusher, Marcy mill, Dorr classifier, 6 Wilfley tables, Callow flotation machines.	140
Graham Consolidated (B).	Clark	Amalgamation and concentration.	1 crusher, 2 Tremain stamps, 1 Wilfley table.	16
Lost Mexican (A)	Unorganized (5 miles east of Bonita).	Amalgamation	Crusher, 1 Wilfley table	5
Greenlee County:				
Detroit Copper (A).	Copper Mountain	Concentration and flotation.	3 Symons crushers, 6 Colorado rolls, 5 Marathon tube mills, 4 Dorr Franz classifiers, 38 Frue and 1 Senn vanner, 25 Wilfley and 6 Overstrom tables, Mineral Separation flotation machines, 2 Oliver filters.	1,500
Gold Belt (B)	do	Amalgamation and concentration.	Crusher, 5 stamps, 1 Frue vanner.	5
Buzzard Shadow (B).	do	Amalgamation	Crusher, 4 Nissen stamps, copper plates.	8
Arizona Copper (A).	Greenlee	Gravity concentration and flotation (two mills).	Morenci mill: 1 McCully gyratory and 2 Symons crushers, 2 Superior and 13 Arizona rolls, 12 Hardinge and 2 other tube mills, 12 Dorr classifiers, 79 Frue and 24 Isbell vanners, 108 National tables, 63 Callow roughing cells, 18 Callow cleaning cells, 2 Oliver filters.	4,000
			Clifton mill: 2 Marcy mills, 8 National tables, 12 Callow roughing cells, 4 Callow cleaning cells, 16 double-deck Deister slime tables, 2 Hardinge mills, 2 drag belt classifiers.	500
Shannon (Custom) (A)	do	Concentration and experimental flotation.	2 crushers, 2 roller mills, 1 tube mill, Allen cones, Janney classifiers, 20 vanners, 12 Wilfley tables, flotation machines.	500
Smart (B)	do	Amalgamation and concentration.	Blake crusher, 1 Nissen stamp, 1 Wilfley table.	10
Maricopa County:				
Relief (B)	Agua Fria	Amalgamation and cyanidation.	Crusher, 1 Lane mill, Allis Chalmers rolls, 4 50-ton tanks.	25

Reduction mills in Arizona in 1917—Continued.

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Maricopa County—Continued.				*Short tons.*
Fort Worth (B)	Cave Creek	Amalgamation and concentration.	5 stamps, 1 table	15
Vulture (A)	Vulture	Amalgamation, concentration and cyandiation.	Gates No. 5 crusher, 20 stamps, 3 5-foot Australian grinding pans, 1 Dorr classifier, 3 Wilfley (No. 5) and 6 Deister slime tables, 200-ton cyanide mill, 4 Dorr 30-foot agitation tanks.	100
Arizona Vermont (B).	White Picacho	Amalgamation and concentration.	Sampson crusher, Ellspass mill, 1 plate, Wilfley table.	15
Sturdy (B)	Winafred	do	Stamps, tables	25
Mohave County:				
Doyle (B)	Aubrey	Amalgamation and cyanidation.	2 percolation tanks	1
Graystone (B)	do	Cyanidation	5 stamps, 1 tank	3
Copperville (B)	Cedar Valley	Concentration	2 Symons disk grinders, 2 Webb City rolls, Overstrom classifier 14, Overstrom tables.	100
Leviathan (A)	do	Concentration and flotation (of molybdenum).	Crusher, rolls, 1 Akins classifier, Mineral Separation flotation.	50
San Francisco (B)	do	Amalgamation and concentration.	Blake crusher, 10 stamps, hydraulic classifier, 1 Frue vanner.	30
Yucca Tungsten (A).	do	Concentration	2 Universal crushers, 2 hydraulic and 1 Bunker Hill classifiers, 3 Card and 4 Wilfley tables, 3 Harz jigs.	50
Walkover (B)	Cottonwood	Amalgamation and concentration.	1 crusher, 14 stamps, 1 Gates table.	20
Cyclopic (B)	Gold Basin	Cyanidation	Dodge crusher, 1 set of Dodge rolls, 5 50-ton Wood tanks.	100
Golden Burro (B)	Greenwood	Amalgamation	2 stamps, plate	5
Nevada Arizona (A).	Hackberry	Amalgamation, concentration, and cyanidation.	Dodge crusher, 1 6-foot Allis Chalmers Chilean mill, 1 Isbell table, 10 agitation tanks.	50
Gold Flats (B)	Maynard	Amalgamation and concentration.	Dodge crusher, 3 stamps, Wilfley table.	12
Arizona & Eastern (B, C).	do	Amalgamation and cyanidation.	Blake crusher, 2 stamps (cyanide plant under construction).	10
Moyle (B)	do	do	Crusher, 1 stamp, 3 tanks, 1 filter.	4
Frisco (B)	San Francisco	Cyanidation	Blake crusher, 3 rolls, 2 tube mills, 2 Dorr classifiers, 2 Dorr thickeners, 6 300-ton Pachuca tanks (agitation), 2 Kelly filter presses.	100
Gold Road (B)	do	do	Gates No. 5 crusher, 40 stamps, 4 tube mills, 6 Dorr duplex classifiers, 16 ore tanks, 3 Pachuca agitation tanks, 2 Dahne slime presses, Butter filter.	300
Secret Pass (B)	do	Amalgamation	5 stamps, plates	20
Pioneer (B)	do	Amalgamation and cyanidation.	Blake crusher, 10 stamps, 7 30-ton tanks.	35
Ruth-Rattan (B)	do	Cyanidation	Gates crusher, 8 stamps, 1 Allis Chalmers tube mill, 3 agitation tanks.	60
Tom Reed (A, C).	do	do	Austin gyratory crusher, 20 stamps, 3 Allis Chalmers ball mills (1 primary grinder and 2 regrinders), 5 Dorr classifiers, 4 Dorr agitators, 9 Dorr thickeners, 2 Merrill filters.	300

Reduction mills in Arizona in 1917—Continued.

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Mohave County—Continued.				*Short tons.*
United Eastern (A, C).	San Franciso	Cyanidation	Telsmith No. 6 gyratory crusher, 2 Marcy mills, 3 Allis-Chalmers concave tube mills, 2 Simplex and 3 Duplex Dorr classifiers, 7 Dorr agitators, 7 Dorr thickeners.	275
Vivian (B)	do	Amalgamation	10 stamps, plates	40
Bi-Metal (B)	Wallapai	do	Blake crusher, 10 stamps, 1 Huntington mill.	35
Arizona Butte (A).	do	Concentration	Crusher, 2 Davis rolls, 1 Delano classifier, 6 Butchart and 1 Wilfley tables (plan jigs and flotation).	150
Emerald Isle) (A, C).	do	Sulphuric-acid leaching and electrolytic precipitation.	1 Dodge crusher, 4 leaching tanks with filter bottoms, 16 cells with lead anodes.	40
Flores (B)	do	Amalgamation	Blake crusher, 5 stamps, ore feeder plates, Gilpin and canvas tables.	15
Washington Arizona (C).	do	Flotation	Fields flotation machines	300
Gem (A)	do	Amalgamation and concentration.	Crusher, 4 Nissen stamps, 3 Standard tables.	30
Keystone (A)	do	Concentration and flotation.	1 Blake crusher, 1 ball mill, 1 Akins classifier, 3 Wilfley tables, Mineral Separation flotation, 1 Dorr thickener.	150
Midnight (B)	do	Amalgamation	10 stamps, plates	30
Minnesota (B)	do	Concentration	1 Dodge and 1 Blake crusher, Chilean mill, 3 Frue vanners, 10 Wilfley tables.	150
Oro Plata (B)	do	do	1 crusher, 2 Nissen stamps, 3 vanners.	15
Union Basin (A)	do	Concentration and flotation.	Crusher, rolls, tables, flotation machines (destroyed by fire October, 1917).	200
Tennessee (custom) (A).	At Needles, Cal	do	Jaw crusher, 3 rolls, 1 tube mill, 3 classifiers, 3 Johnson and 1 Isbell vanners, 8 Wilfley and 3 Deister tables, flotation machines, 2 Portland filters.	240
Utah-Arizona (A)	Weaver	Amalgamation and concentration.	1 Blake crusher, 5 stamps, plates, 1 Lane mill, 2 Wilfley tables.	50
Pima County:				
New Cornelia (A)	Ajo	Sulphuric-acid leaching and electrolytic precipitation.	5 Gates gyratory crushers, 12 Symons vertical disk pulverizers, 12 leaching tanks 88 by 88 by 15 feet, 5 solution tanks 60 by 90 by 11 feet, 152 electrolytic tanks and lead anodes.	5,000
Old Yuma (B)	Amole	Concentration	Gyratory crusher, 3 rolls, 2 tables.	250
International Tungsten (A).	Arivaca	do	2 crushers, 10 stamps, 8 Wilfley tables, Johnson vanner.	100
Wedge (B)	Pima	do	1 crusher, 1 set of rolls, Lane mill, 1 classifier, 5 tables, jigs.	100
Welden (A)	Quijotoa	Amalgamation and concentration.	Gates crusher, 5 stamps, 3 Standard tables.	25
Isabelle (B)	Saltwell	Amalgamation	Lane mill	40
El Tiro (B)	Silver Bell	Concentration	Huntington mill, Richards classifier, 3 tables.	100
Pinal County:				
Copper State (A).	Bunker Hill	Concentration and flotation.	1 Marcy mill, Dorr duplex classifier, 7 Wilfley tables, 5 Callow cells, 1 Oliver filter.	150
Silver Reef (B)	Casa Grande	Cyanidation	Crusher, 20 stamps, 1 12-foot tube mill, 10 tanks.	50
Vekol (B)	do	Concentration	10 stamps, tables	50
Bulldog (B)	Goldfields	Amalgamation and cyanidation.	2 stamps, 3 percolation tanks	5
Mammoth or Goldfield (B).	do	do	Gates crusher, 20 stamps, 3 50-ton percolation tanks.	50

Reduction mills in Arizona in 1917—Continued.

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Pinal County—Con.				*Short tons.*
Ray Hercules (C).	Mineral Creek....	Concentration and flotation.	2 Gates crushers (at mine), 2 Traylor rolls, 6 Hardinge and 3 Marcy mills, 9 Dorr classifiers, 15 Overstrom tables, 42 flotation cells, 3 Oliver filters.	1,500
Campo Bonita(B)	Old Hat..........	Amalgamation and concentration.	5 stamps, tables..............	15
Mammoth Collins (A).	.....do............	Concentration.......	McCully No. 3 crusher, 1 Marcy mill, 1 Senn pan vanner, 7 Wilfley and 2 Card tables.	175
Superstition Cons. (B).	Pioneer..........	Concentration and flotation.	Crusher, tables, flotation machines.	50
Magma (A)......	.....do............	.....do...............	2 crushers, 4 tube and ball mills, drag classifier, 13 Wilfley and 4 Deister tables, flotation cells.	350
Silver King (C)..	.....do............	Concentration and flotation experiments, 1917.	Crusher, Butchart table, K. & K. flotation (plan 50-ton Marcy mill).	100
Superstition Mountain (B).	.....do............	Concentration.......	Crusher, Huntington mill, 1 double-deck Wilfley table.	20
Kelvin - Sultana (B).	Riverside..........	.....do...............	Gates gyratory crusher, Symons disk pulverizer, rolls, 1 8-foot Hardinge mill, 1 Richards-Janney mill, 5 Wilfley, and 5 Deister tables.	250
Santa Cruz County:				
Montana (A).....	Oro Blanco.......	Concentration and flotation.	Crusher, tables, flotation cells. cells.	100
Duquesne (A)....	Patagonia........	Flotation and concentration.	Crusher, Marcy ball mill, 2 drag classifiers, 3 Callow cells, 2 Oliver filters.	100
Wandering Jew (A).	Tyndall..........	Concentration.......	Crusher, rolls, 1 classifier, 1 vanner, 1 Wilfley table.	75
Lower California Metals Co. (custom) (C).	Near Nogales.....	Concentration and flotation.	1 Blake crusher, 2 ball mills, 1 Knapp classifier, 2 Wilfley tables, flotation cells.	100
Yavapai County:				
Binghamton (A).	Agua Fria.........	.....do...............	Crusher, Dorr classifier, 3 Deister and 1 Butchart table, Inspiration flotation, 3 Oliver filters.	250
Consolidated Arizona (A)....	Big Bug (at Humboldt).	.....do...............	1 Blake and 1 Symons crusher, 3 Hardinge and 1 Allis Chalmers tube mills, 1 Caldecott classifier, 2 Buchart and 2 Wilfley tables, Mineral Separation flotation, 1 Portland filter.	500
Henrietta (B)....	Big Bug..........	Amalgamation, concentration, and cyanidation.	1 crusher, 20 stamps, 3 Wilfley tables, 12 percolation tanks (old).	60
Fortune (B)......	.....do............	Amalgamation and concentration.	Jaw crusher, 10 stamps, 3 Wilfley tables.	80
Jones (A)........	.....do............	.....do...............	Austin No. 2 gyratory crusher, 10 stamps, 2 Wilfley tables, 4 25-ton tanks.	18
Lelan (B)........	.....do............	.....do...............	Blake crusher, 10 stamps, 2 Wilfley tables.	40
Dividend (B)....	.....do............	.....do...............	1 crusher, 10 stamps, 1 Wilfley table.	20
Oriental (B).....	.....do............	.. Concentration.....	2 crushers, 1 Ellspass mill, 1 hydraulic classifier, 2 Standard and 2 Bartlett tables.	40
Poland (B).......	.....do............	Amalgamation, concentration.	Crusher, 20 stamps, card tables.	100
McCabe - Gladstone (B).	.....do............	Concentration.......	1 Gyratory crusher, 10 stamps, 3 Standard and 1 Wilfley tables.	65
Golden Belt (B)..	Black Canyon....	Amalgamation, concentration.	1 Dodge crusher, 2 Tremain steam stamps, 1 Wilfley table (plan cyanide mill in 1918).	12

Reduction mills in Arizona in 1917—Continued.

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Yavapai County—Continued.				*Short tons.*
Parker (B)	do	do	1 Dodge crusher, 5 stamps, 1 Standard table.	24
Big Blue (B)	Black Rock	Concentration	Bryan mill, 1 Deister and 1 Wilfley table, Deister slimer.	40
Oro Grande (B)	do	Amalgamation	1 Dodge crusher, 10 stamps	60
Dark Horse (B)	do	Amalgamation, concentration, and cyanidation	Crusher, 20 stamps, plates, 6 vanners, 6 percolation tanks.	80
Ventura (B)	Castle Creek	Concentration	1 crusher, 1 modified Lane mill.	5
Gold Lode (B)	Cherry Creek	Amalgamation and concentration.	Blake crusher, 10 stamps, 2 Frue vanners.	40
Federal (B)	do	Amalgamation, concentration, and cyanidation.	Blake crusher, 1 Dorr classifier, 2 Wilfley tables, 6 agitation tanks.	75
Golden Idol (B)	do	Amalgamation and concentration.	1 Blake crusher, 3 stamps, 1 Wilfley table.	10
Statehood (B)	do	Amalgamation, concentration, and cyanidation.	1 crusher, 5 stamps, 1 Standard table, 2 percolation tanks.	15
Verde Inspiration (B).	do	Amalgamation and concentration.	2 crushers, 3 stamps, classifiers, 2 vanners, 2 tables.	21
Arizona Mines & Reduction Co. (custom mill and sampler) (A).	At Wickenburg	Concentration and flotation.	Ball mills, classifiers, 3 Wilfley tables, special flotation (also 300-ton sampler).	50
Hub (B)	Copper Basin	Amalgamation	3 stamps, plates	10
Belle (Miller) (B).	Eureka	do	1 Dodge crusher, 1 Chilean mill.	10
Hillside (B)	do	Concentration	Crusher, 5 stamps, 1 Wilfley table, 1 slimer.	15
Nieman (A)	do	Amalgamation and cyanidation.	Crusher, 10 stamps, 1 agitation tank.	10
Big Pine (A)	Hassayampa	Cyanidation	1 Blake crusher, 1 tube mill, 1 ball mill, 2 classifiers, 3 agitation tanks, Oliver filter (partly destroyed by fire December, 1917).	80
Cash (Y. P.) (B).	do	Amalgamation and concentration.	Blake crusher, 10 stamps, 1 Huntington mill, 1 Monell classifier, 4 Wilfley and 3 Monell tables, 1 Monell slimer.	30
Climax (B)	do	do	Blake crusher, 10 stamps, 2 Wilfley tables.	25
Emporia (B)	do	do	1 Blake crusher, 5 stamps, 2 Wilfley tables.	15
Independence (B)	do	Cyanidation	Jaw crusher, Lane mill, 8 tanks (4 agitation).	20
Juanita (B)	do	Amalgamation	2 stamps, plates	7
Midnight Test (B)	do	Amalgamation and concentration.	1 Blake crusher, 6 Nissen stamps, 1 Frue vanner, 2 new Standard tables.	40
Dunkirk (Castle) (B).	do	Concentration and flotation.	4 Nissen stamps, 3 Wilfley tables, flotation cells.	40
Mount Union (B)	do	Amalgamation and concentration	Crusher, Huntington mills, plates, tables.	60
Sundance (B)	do	Concentration	1 crusher, 5 stamps, 3 rolls, 1 Standard table.	20
Sunnyside (B)	do	Amalgamation and concentration.	Crusher, Huntington mills, plates, tables.	25
Venezia (B)	do	do	2 crushers, 20 stamps, 2 Wilfley tables.	100
Empire (B)	do	Concentration	Crusher, 10 stamps, 1 table	40
Acquisition (B)	Humbug	Amalgamation and concentration.	1 Austin crusher, 10 stamps, 2 classifiers, 1 Allis Chalmers vanner, 2 Wilfley tables.	20
American Gold (B).	do	Amalgamation, concentration, and cyanidation.	Blake crusher, 10 stamps, 2 Wilfley tables, 40-ton cyanide plant (4 percolation tanks).	20
Congress (B).	Martinez	Concentration and cyanidation.	4 Blake crushers, 40 stamps, 10 Standard tables, 6 Frue vanners, 9 ore tanks.	200
Alaska (B)	do	do	4 Nissen stamps, tables, agitation tanks.	30

Reduction mills in Arizona in 1917—Continued.

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Santa Cruz County—Continued.				*Short tons.*
Buster (B)	Pine Grove	Amalgamation and concentration.	8 stamps, tables	20
Old Tiger (B, C)	do	Concentration and flotation.	Blake crusher, ball mill, drag classifier, Callow flotation cells.	100
Derby (Madezille) (B).	Thumb Butte	Amalgamation and concentration.	Crusher, 5 stamps, 1 Frue vanner.	10
Crown King (A, C).	Tiger	Concentration and flotation.	1 Dodge crusher, 1 Allis Chalmers ball mill, 1 Dorr classifier, 6 Wilfley tables, Callow flotation.	75
Lincoln (B)	do	Amalgamation and concentration.	Hendrie & Bolthof crusher, 15 stamps, 2 Allis Chalmers vanners, 3 Wilfley tables.	45
Tiger or Oro Belle (A).	do	do	Jaw crusher, 20 stamps, 2 Wilfley tables.	70
Cumberland (B).	Turkey Creek	do	Crusher, 10 stamps, 2 Wilfley tables.	25
Copper Chief (A).	Verde	Cyanidation	Blake crusher, 1 Stearns Roger ball mill, 1 tube mill, 1 Dorr classifier, 3 Dorr thickeners, 4 Dorr agitation tanks, 2 Oliver filters (contemplate changing process to chloridizing roast).	100
El Toro (B)	Walker	Amalgamation	3 stamps (will add crusher and table).	7
Homestead (B)	do	do	5 stamps, plates	15
Pine Mountain (B).	do	Amalgamation and concentration.	Blake crusher, 10 stamps, 2 Wilfley tables.	20
Mudhole (B)	do	do	Crusher, 3 Huntington mills, 4 Wilfley tables.	100
Malapai (B)	Walnut Grove	do	Crusher, 1 stamp, 1 Standard table.	16
Isabella (Old Spaniard) (B).	do	Amalgamation	Dodge crusher, 1 3½-foot Huntington mill.	12
Rochester (B)	do	Amalgamation, concentration, and cyanidation.	10 stamps, tables, tanks	30
Alvarado (B)	Weaver	Cyanidation	Crusher, 20 stamps, 2 tube mills, cone classifiers, 2 Hendryx & Butters agitation tanks, Butters filters (60 frame).	150
Yarnell (B)	do	Amalgamation and cyanidation.	Blake crusher, 20 stamps, plates, tanks, filter press.	60
Mayflower (B)	do	Amalgamation and concentration.	Crusher, 10 stamps, 2 Wilfley tables.	35
Monica (A)	do	Amalgamation and cyanidation.	20 stamps, plates, tanks	60
Octave (B)	do	Amalgamation, concentration, and cyanidation.	2 Blake crushers, 40 stamps, 6 Wilfley tables, 8 ore tanks (old; will be remodeled).	100
Gold King (B)	do	Amalgamation and concentration.	1 crusher, 2 stamps, 1 Frue vanner.	12
Monarch (B)	White Picacho	Concentration	Crusher, stamps, tables	100
Producer (B)	do		1 180-pound stamp, capacity about 200 pounds of ore in 24 hours, used for sampling.	
Yuma County:				
Big Eye (B)	Castle Dome	Amalgamation and cyanidation.	Blake crusher, 5 stamps, 3 Trent agitation tanks.	10
Hull No. 1 (A)	do	Concentration	Crusher, 2 rolls, 1 Delano classifier, 2 Wilfley tables, and 1 Deister table.	100
Henneys (C)	do	do	Joshua Hendy crusher, 1 Stebbins table.	50
Bonanza & Golden Eagle (B).	Ellsworth	Amalgamation	40 stamps, plates	120
Copper Belt (B)	do	do	10 stamps, plates	40
Socorro (B)	do	Amalgamation, concentration, and cyanidation.	20 stamps, tables, tanks	60
Fortuna (B)	Fortuna	Amalgamation	20 stamps (1,400 pounds), plates.	70

Reduction mills in Arizona in 1917—Continued.

Name.	District.	Process.	Equipment.	Approximate maximum daily capacity.
Yuma County—Continued.				*Short tons.*
King of Arizona (B).	Kofa	Cyanidation	Crusher, rolls, tube mills, agitation tanks.	200
Scott (B)	Plomosa	Amalgamation and concentration.	Blake crusher, 1 stamp, 1 Standard table.	7
Stafford (B)	do	Amalgamation	Blake crusher, Lane slow-speed mill.	20
Red Cloud Consolidated (C).	Silver	Concentration	Crusher, 2 sets of rolls, Egglesten ball mill, 3 Stebbins dry tables (burned in 1918).	300

IRON ORE, PIG IRON, AND STEEL.[1]

By Ernest F. Burchard.

INTRODUCTION.

Throughout 1917 war-time activity continued to prevail in the iron industry. The phenomenal records of shipments of iron ore and production and shipments of pig iron made in 1916 were not quite reached, owing to unfavorable weather and to shortage of labor, boats, and other transportation facilities, and of coal and coke. Cooperation between furnace men, transportation companies, and ore producers resulted in the successful movement and equitable distribution of ore, without which the production of pig iron would have suffered much more serious handicaps. Government control of prices, supplies, and products also aided in preventing an acute shortage of ore and metal needed for war purposes. The quantity of iron ore mined showed a small increase, contributed by southern and eastern districts.

The American iron and steel industry is the bulwark upon which not only the United States but her allies have depended for munitions, armaments, and ships, and the patriotic response of this industry as a whole to the call for increased production of steel has won grateful public acknowledgment from those in high command.

Extraordinary economic conditions prevailed in 1917. Demand for iron and steel was world-wide and at all times greatly exceeded supply. During the first half of the year, in the absence of regulations and restrictions, prices rose to unprecedented levels and would have gone still higher had the fundamental relations between supply and demand been allowed free sway. In the second half of the year the United States Government became a large purchaser and Federal regulation of prices and distribution of products were put into effect. Production was in nowise curtailed, however, as the war needs of the United States and the allied governments far exceeded the iron and steel making capacity.

Estimates by the Geological Survey of the production, shipments, and stocks of iron ore in 1917 were released on January 24, 1918, and comparison of these figures with the final ones published in this report indicate that the estimates of production and shipments were respectively only 0.05 per cent and 0.1 per cent high, and that stocks was 0.65 per cent low.

---

[1] The statistics of iron ore, pig iron, and steel were compiled by J. H. Winchell and H. W. Davis, those of ferroalloys by Miss M. B. Clark, and the imports and exports by J. A. Dorsey.

IRON ORE.

IRON ORE MINED AND SHIPPED IN 1917.

The iron ore mined in the United States in 1917, exclusive of that containing 5 per cent or more of manganese,[1] amounted to 75,288,851 gross tons, as compared with 75,167,672 gross tons mined in 1916, an increase of 121,179 gross tons, or 0.16 per cent. Beneficiated ore, instead of crude ore mined, is included in these figures, if the ore is treated in any way. The quantity of iron ore shipped from the mines in the United States in 1917 amounted to 75,573,207 gross tons, valued at $238,260,444, as compared with 77,870,553 gross tons, valued at $181,902,277, shipped in 1916. This represents a decrease in quantity of 2,297,346 gross tons, or 2.95 per cent, and an increase in value of $56,358,167, or 30.98 per cent, as compared with shipments in 1916. The average price of ore per ton at the mines for all grades of ore for the whole country in 1917 was $3.15, as compared with $2.34 in 1916. These quantities of ore, both mined and shipped, include the iron ore used for fluxing other metallic ores at smelters in the Western States, but the shipments do not include the iron ore sold for the manufacture of paint. The quantity of iron ore sold for the manufacture of paint in 1917 amounted to 18,656 tons, valued at $56,859, or $3.05 per ton, compared with 16,968 gross tons, valued at $45,256, or $2.67 per ton in 1916.

The ore reported as sold for fluxing other than in the manufacture of pig iron amounted to 107,793 gross tons, valued at $374,441, in 1917, as compared with 88,601 gross tons, valued at $288,089, in 1916. The domestic iron ore actually sold for the manufacture of pig iron amounted in 1917 to 75,465,414 gross tons, valued at $237,886,003, as compared with 77,781,952 gross tons, valued at $181,614,188, in 1916.

A graphic comparison of the annual production of iron ore and its derived metals since 1870 is afforded by the curves shown in figure 6. It must be borne in mind, however, that the figures for the three products are not strictly comparable, because considerable foreign iron ore and also some cinder, scale, and scrap enter into the production of pig iron, and considerable quantities of scrap iron and steel, as well as cinder and scale, enter into the production of new steel.

IRON ORE MINED AND SHIPPED, BY STATES.

Iron ore was mined in 25 States in 1917, as compared with 24 States in 1916, Ohio having dropped out and Arkansas and Montana having been added as producers in 1917. Of these States, California, Montana, and Nevada produced iron ores for metallurgic flux only; part of the production of Colorado, New Mexico, and Utah was used for smelter flux and part for pig iron and ferroalloys; the remaining States produced iron ore mainly for use in blast furnaces, except small quantities used for paint from Georgia, Michigan, New York, Pennsylvania, and Wisconsin. The output in the three States producing the largest quantity of iron ore—Minnesota, Michigan, Alabama—was about the same as in 1916, and New York and Wisconsin, in addition, each produced more than 1,000,000 tons of ore. The Minnesota iron ranges are producing more iron ore than all the rest of the States together, having furnished nearly 60 per cent of the total for the United States in recent years.

---

[1] The production of manganiferous iron ore is stated in the chapter on manganese and manganiferous ores in Mineral Resources for 1917.

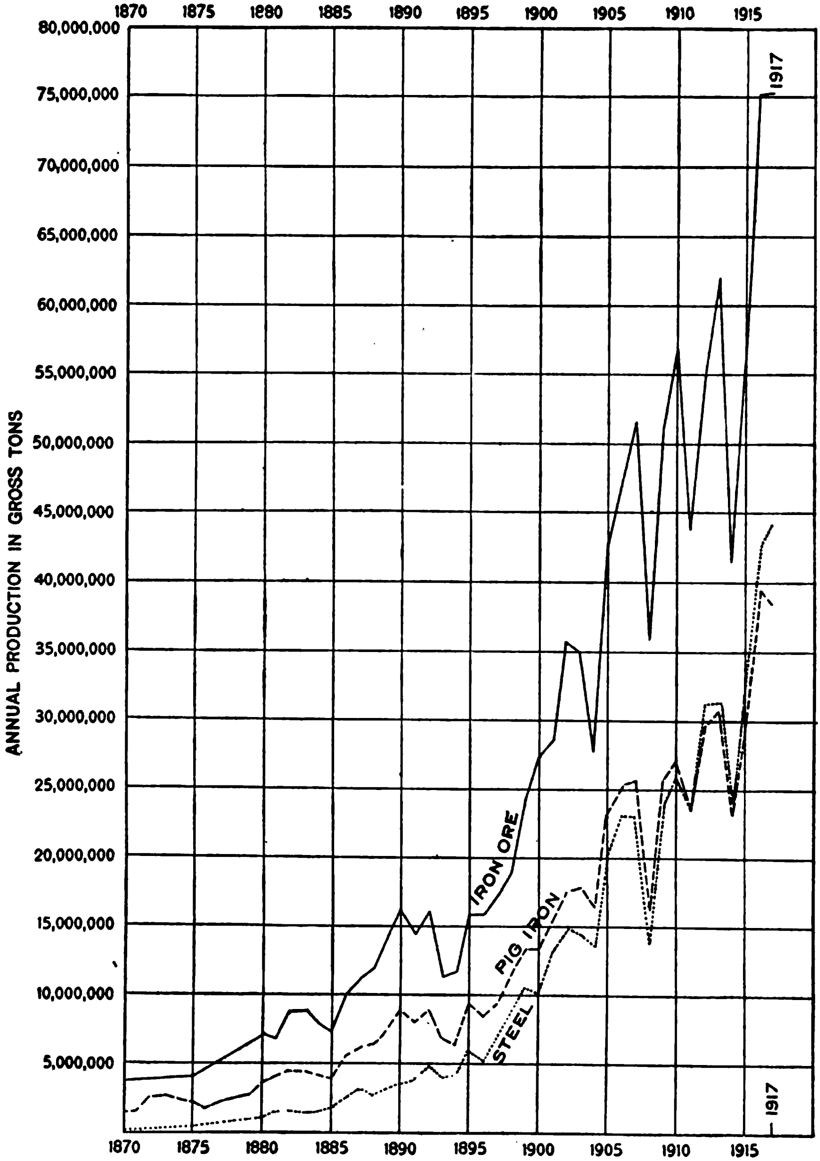


FIGURE 6.—Curves showing annual production of iron ore, pig iron, and steel in the United States, 1870 to 1917.

IRON-ORE SHIPMENTS.

The following table, showing the iron ore shipped from the mines in 1916 and 1917, by States, is given precedence over the table showing the quantity mined because the table of shipments is the only one in which values are recorded:

Iron ore shipped from mines in the United States, 1916 and 1917, by States.

State.	1916		1917		Increase or decrease in 1917.		Percentage of increase or decrease in 1917.	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity.	Value.
Alabama	6,801,839	$10,843,231	7,101,586	$13,049,535	+ 299,747	+$2,206,304	+ 4.4	+ 20.3
California	2,970	11,880	2,207	8,828	− 763	− 3,052	−25.7	− 25.7
Georgia	252,143	413,259	211,501	524,175	− 40,642	+ 110,916	−16.1	+ 26.8
Maryland	(a)	(a)	10,730	40,423	(b)	(c)	(b)	(c)
Michigan	18,995,797	49,054,340	17,712,916	62,833,624	−1,282,881	+13,779,284	− 6.8	+ 28.1
Minnesota	45,869,251	106,628,784	44,962,127	142,901,148	− 907,124	+36,272,364	− 2.0	+ 34.0
Missouri	34,914	116,484	38,770	134,906	+ 3,856	+ 18,422	+11.0	+ 15.8
New Jersey	528,084	1,877,056	474,708	2,341,160	− 53,376	+ 464,104	−10.1	+ 24.7
New Mexico	157,779	168,157	231,604	381,275	+ 73,825	+ 213,118	+46.8	+126.7
New York	1,464,917	5,571,429	1,356,011	7,381,333	− 108,906	+ 1,809,904	− 7.4	+ 32.5
North Carolina	(a)	(a)	90,957	445,898	(b)	(c)	(b)	(c)
Ohio	(a)	(a)	0	0	(b)	(c)	(b)	(c)
Pennsylvania	558,556	702,633	548,674	873,320	− 9,882	+ 170,687	− 1.8	+ 24.3
Tennessee	467,741	736,397	520,460	1,235,718	+ 52,719	+ 499,321	+11.3	+ 67.8
Virginia	486,798	1,000,118	472,337	1,182,449	− 14,461	+ 182,331	− 3.0	+ 18.2
Wisconsin	1,529,459	3,644,542	1,179,709	3,913,437	− 349,750	+ 268,895	−22.9	+ 7.4
Other States[d]	720,305	1,133,967	658,910	1,013,215	+ [b] 40,292	+ [c] 365,569	+[b]5.6	+[c]32.2
	77,870,553	181,902,277	75,573,207	238,260,444	−2,297,346	+56,358,167	− 2.95	+ 30.98

[a] Less than three shippers in Maryland, North Carolina, and Ohio, in 1916, and permission not granted to publish State totals. Figures for these States, therefore, included in "Other States."

[b] Increase for North Carolina and decrease for Maryland and Ohio included with those for "Other States."

[c] Increase for Maryland and North Carolina and decrease for Ohio included with those for "Other States."

[d] 1916: Colorado, Connecticut, Iowa, Maryland, Massachusetts, Nevada, North Carolina, Ohio, Utah, West Virginia, and Wyoming. 1917: Arkansas, Colorado, Connecticut, Iowa, Massachusetts, Montana, Nevada, Utah, West Virginia, and Wyoming.

IRON ORE MINED, BY VARIETIES, BY STATES, AND BY MINING DISTRICTS.

Iron minerals comprise sulphides, oxides, carbonates, silicates, and phosphates, of which only the oxides and the carbonates are used in the iron and steel industry, except a small quantity of oxide by-products from sulphide ores used in the manufacture of sulphuric acid. The ores of iron are generally classed under the four heads, hematite, brown ore, magnetite, and carbonate.[1]

Hematite has always been predominant as an ore of iron, and in 1917 it constituted nearly 94 per cent of the iron ore mined in the United States. Brown ore and magnetite are far below it in importance, having together furnished in 1917 a little more than 6 per cent of the total production of iron ore. The production of iron carbonate is insignificant in comparison with that of the other ores; in 1916 it constituted only about 0.002 per cent of the total, and in 1917 none was reported to have been mined.

---

[1] Notes concerning the composition of these types of ores are given in U. S. Geol. Survev Mineral Resources, 1916, pt. 1, pp. 537-541, 1918.

Iron ore mined in the United States in 1916 and 1917, by States and varieties, in gross tons, with percentage of increase or decrease in 1917.

State.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total quantity.	Percentage of increase or decrease in 1917.
1916.						
Alabama	5,672,005	1,075,896			6,747,901	
California			3,000		3,000	
Georgia	110,647	146,302			256,949	
Iowa		11,351			11,351	
Maryland		4,455			4,455	
Michigan	18,071,016				18,071,016	
Minnesota	44,585,422				44,585,422	
Missouri	27,568	7,346			34,914	
Nevada		9,910			9,910	
New Jersey			493,004		493,004	
New Mexico			157,779		157,779	
New York	74,723	(a)	[a]1,267,784		1,342,507	
North Carolina		4,263	60,043		64,306	
Ohio				1,800	1,800	
Pennsylvania		16,031	543,400		559,431	
Tennessee	256,093	192,541	7,200		455,834	
Utah		45,514			45,514	
Virginia	80,258	[b] 360,234	(b)		440,492	
West Virginia		3,605			3,605	
Wisconsin	1,304,518				1,304,518	
Wyoming	545,774				545,774	
Other States [c]		28,190			28,190	
	70,728,024	1,904,484	2,533,364	1,800	75,167,672	
1917.						
Alabama	5,949,096	1,088,611			7,037,707	+ 4.29
Arkansas	40				40	
California			2,207		2,207	− 26.43
Georgia	101,805	124,735			226,630	− 11.80
Iowa		22,612			22,612	+ 99.2
Maryland	[d] 11,830	(d)			11,830	+165.54
Massachusetts		10,000			10,000	(e)
Michigan	17,868,601				17,868,601	− 1.12
Minnesota	44,595,232				44,595,232	+ 0.02
Missouri	26,866	12,042			38,908	+ 11.44
Nevada		1,010			1,010	− 89.79
New Jersey			489,943		489,943	− 0.62
New Mexico	25,471		211,750		237,221	+ 50.35
New York	[f] 53,514	(f)	1,250,803		1,304,317	− 2.84
North Carolina		35,644	55,353		90,997	+ 41.50
Pennsylvania		4,927	541,773		546,700	− 2.28
Tennessee	260,038	247,340	1,151		508,529	+ 11.56
Utah		48,058			48,058	+ 5.59
Virginia	109,166	360,711	26		469,903	+ 6.68
West Virginia		4,632			4,632	+ 28.48
Wisconsin	1,202,235				1,202,235	− 7.84
Wyoming	543,846				543,846	− 0.35
Other States [g]		27,693			27,693	+[e]33.71
	70,743,513	1,992,332	2,553,006		75,288,851	+ 0.16

[a] Brown ore included in magnetite.
[b] Magnetite included in brown ore.
[c] Colorado, Connecticut, and Massachusetts, in 1916.
[d] Brown ore included in hematite.
[e] Less than three producers in Massachusetts in 1916, and permission not granted to publish State total. Increase in 1917, therefore, included in "Other States."
[f] Brown ore included in hematite.
[g] Colorado, Connecticut, and Montana, in 1917.

The principal iron-mining districts in the United States, except the Adirondack and Birmingham districts, are interstate and the different varieties of ore are to a large extent locally segregated, so that statistics of production by districts are of more general interest and importance than statistics by States. The Lake Superior district, comprising all the mines in Minnesota and Michigan and those in northern Wisconsin, mined 63,481,321 gross tons in 1917, nearly all hematite, compared with 63,735,088 gross tons in 1916, a decrease of 0.39 per cent. This district mined nearly 85 per cent of the total ore in 1916 and 1917. The Birmingham district, in north central Alabama, mined 6,187,073 gross tons of ore, including both hematite and brown ore, in 1917, compared with 5,976,018 tons in 1916, an increase of 3.53 per cent. This district therefore mined about 8 per cent of the total, or a little less than one-tenth as much as the Lake district. The Adirondack district, New York, mined 1,100,001 gross tons of magnetite in 1917, compared with 1,077,638 tons in 1916, an increase of 2.07 per cent. None of the other individual districts mined as much as 1,000,000 tons. The production in 1917 of the several districts was not greatly different from their production in 1916, and is an indication that about the maximum capacity under the prevailing conditions of shortage in labor and cars had been reached.

Iron ore[a] mined in the United States, by mining districts and varieties, in 1916 and 1917, in gross tons.

1916.

District.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total.
Lake Superior[b]	63,735,088	....	....	....	63,735,088
Birmingham	5,461,444	514,574	....	....	5,976,018
Chattanooga	540,405	296,218	....	....	836,623
Adirondack	....	....	1,077,638	....	1,077,638
Northern New Jersey and southeastern New York	....	(c)	[c] 683,150	....	683,150
Other districts	991,087	1,093,346	772,922	1,800	2,859,155
	70,728,024	1,904,484	2,533,364	1,800	75,167,672

1917.

District.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total.	Percentage of change in 1917.
Lake Superior[b]	63,481,321	....	....	....	63,481,321	−0.39
Birmingham	5,728,862	458,211	....	....	6,187,073	+3.53
Chattanooga	524,787	296,698	....	....	821,485	−1.81
Adirondack	....	....	1,100,001	....	1,100,001	+2.07
Northern New Jersey and southeastern New York	....	(c)	[c] 642,232	....	642,232	−5.99
Other districts	1,008,543	1,235,936	812,260	....	3,056,739	+6.91
	70,743,513	1,992,332	2,553,006	....	75,288,851	+0.16

[a] Exclusive of ore containing 5 per cent or more of manganese.
[b] Includes only those mines in Wisconsin which are in the true Lake Superior district.
[c] A small quantity of brown ore included in magnetite.

These tables show that the greater part of the hematite comes from the Lake Superior district (Michigan, Minnesota, and Wisconsin) and Alabama, the bulk of the brown ore from the southern Appalachian districts, and the magnetite from New York, Pennsylvania, and New Jersey. The iron carbonate is mined in Ohio; (none was mined in 1917. On a later page is given the production of the principal ranges in the Lake Superior district. The bulk of the Lake Superior hematite is more or less hydrated and many deposits include masses of brown ore having varying percentages of combined water. There is, however, a complete gradation from anhydrous hematite to limonite, and as there is no sharp dividing line and as also the greater part of the ore is nearer the anhydrous than the completely hydrated condition, the production of the hydrated ores is included in the production of hematite. Certain mines in northern Michigan produce an ore which is locally termed magnetite. It is a coarsely crystalline anhydrous ore, consisting dominantly of hematite, but having sufficient quantities of magnetite distributed through it to render the ore strongly magnetic. This magnetic ore is also included with hematite in the tables of production, both because it is not a true magnetite and because the quantity is not of sufficient importance to warrant making additional tables for magnetic ores.

The Birmingham and Adirondack districts were the only large iron-ore producing districts that showed increase in output, as compared with 1916.

TOTAL OUTPUT OF IRON ORE.

The following table shows the production of various types of iron ore in the United States as far as it has been recorded or estimated. The statistics from 1889 to the present were collected by the United States Geological Survey; those for 1880 were collected for the census report of that year; those for 1881 were estimated by I. L. Bell;[a] and those from 1882 to 1888, inclusive, were estimated by James M. Swank[b] from the pig iron produced. Figures are not available for the production of various classes of iron ores prior to 1889, except for the census year 1880. The figures for the years prior to 1880 were calculated from the pig iron produced, which included imported ore as well as domestic ore used.

Iron ore mined in the United States, 1810–1917, in gross tons.

Year.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total.
1810–1869					49,656,000
1870 [c]–1879					44,570,527
1880	2,243,993	1,918,622	2,134,2.6	823,471	7,120,362
1881					7,119,643
1882					8,700,000
1883					8,800,000
1884					7,718,129
1885					7,600,000
1886					10,000,000
1887					11,300,000
1888					12,062,530
1889	9,056,288	2,523,087	2,506,415	432,251	14,518,041
1890	10,527,650	2,559,938	2,570,838	377,617	16,036,043
1891	9,327,398	2,757,564	2,317,108	189,108	14,591,178
1892	11,646,619	2,485,101	1,971,965	192,981	16,296,666
1893	8,272,637	1,849,272	1,330,886	134,834	11,587,629
1894	9,347,434	1,472,748	972,219	87,278	11,879,679
1895	12,513,995	2,102,358	1,268,222	73,039	15,957,614
1896	12,576,288	2,126,212	1,211,526	91,423	16,005,449
1897	14,413,318	1,961,954	1,059,479	83,295	17,518,046
1898	16,150,684	1,989,681	1,237,978	55,373	19,433,716
1899	20,004,399	2,869,785	1,727,430	81,559	24,683,173
1900	22,708,274	3,231,089	1,537,551	76,247	27,553,161
1901	24,006,025	3,016,715	1,813,076	51,663	28,887,479
1902	30,532,149	3,305,484	1,688,860	27,642	35,554,135
1903	30,328,654	3,080,399	1,575,422	34,833	35,019,308
1904	23,839,477	2,146,795	1,638,846	19,212	27,644,330
1905	37,567,065	2,546,662	2,390,417	21,999	42,526,133
1906	42,481,375	2,781,063	2,469,294	17,996	47,749,728
1907	46,060,486	2,957,477	2,679,067	23,589	51,720,619
1908	31,788,564	[d]2,620,390	[d]1,547,797	26,585	35,983,336
1909	46,208,640	[d]2,839,265	[d]2,229,839	16,527	51,294,271
1910	51,367,007	[d]2,993,744	[d]2,631,835	22,320	57,014,906
1911	39,626,224	2,032,094	2,202,527	15,707	43,876,552
1912	51,345,782	1,614,486	2,179,533	10,346	55,150,147
1913	57,933,251	1,682,063	2,357,274	7,849	61,980,437
1914	38,286,670	1,537,750	1,610,203	5,138	41,439,761
1915	52,227,324	1,488,709	1,807,002	3,455	55,526,490
1916	70,728,024	1,904,484	2,533,364	1,800	75,167,672
1917	70,743,513	1,992,332	2,553,006		75,288,851
					1,202,531,741

---

[a] Principles of the manufacture of iron and steel, p. 451, 1884.
[b] U. S. Geol. Survey Mineral Resources, 1882 to 1888.
[c] Includes ore produced by owners of blast furnaces, estimated by census at 800,000 tons.
[d] Some brown ore included in magnetite.

PRINCIPAL IRON-ORE MINES.

In 1917 there were 452 iron-ore mines active, compared with 405 in 1916, and 240 mines in 1917 produced more than 50,000 gross tons of iron ore each, compared with 222 mines in 1916. The total ore produced by the mines whose output was more than 50,000 gross tons each was 72,822,173 gross tons, or more than 96 per cent of the entire production of the United States in 1917. Of these 240 mines, 11 (1 less than in 1916) produced more than 1,000,000 tons of iron ore each in 1917. First place in 1917 was held by the Hull-Rust mine, at Hibbing, Minn.; second place by the Red Mountain group, near Bessemer, Ala.; third place by the Mahoning, at Hibbing, Minn.; and fourth place by the Fayal, at Eveleth, Minn. The production of these mines in 1917 was, respectively, 6,468,483 tons, 2,955,022 tons, 2,525,145 tons, and 2,022,816 tons, compared with 7,658,201 tons, 2,899,588 tons, 2,215,788 tons, and 2,252,008 tons, respectively, in 1916. Eight of the 11 mines producing more than 1,000,000 tons in 1917 are in Minnesota. The largest producer in Michigan in 1917 was the Norrie group, which reported having mined 1,384,002 gross tons of hematite, a slight decrease from the production in 1916. Permission has been granted to the Survey by the owners and operators of 212 of these large mines to publish their production, and these statistics are given in the following table:

Iron-ore mines of the United States that produced more than 50,000 gross tons each in 1917.

Rank.	Name of mine.	State.	Nearest town.	Variety of ore.	Quantity mined.
1	Hull-Rust	Minnesota	Hibbing	Hematite	6,468,483
2	Red Mountain group	Alabama	Bessemer	do	2,955,022
3	Mahoning	Minnesota	Hibbing	do	2,525,145
4	Fayal	do	Eveleth	do	2,022,816
5	Canisteo	do	Coleraine	do	1,643,226
6	Morris	do	Hibbing	do	1,605,701
7	Kerr	do	do	do	1,586,409
8	Sellers	do	do	do	1,575,057
9	Adams	do	Eveleth	do	1,549,658
10	Norrie group	Michigan	Ironwood	do	1,384,002
11	Wakefield	do	Wakefield	do	1,061,721
12	Newport and Bonnie	do	Ironwood	do	986,853
13	Woodward 1, 2, and 3	Alabama	Lipscomb	do	877,637
14	Holman	Minnesota	Taconite	do	835,464
15	Bennett	do	Keewatin	do	791,545
16	Leonidas	do	Eveleth	do	782,343
17	Witherbee, Sherman & Co. (Inc.).	New York	Mineville	Magnetite	780,131
18	Dean	Minnesota	Buhl	Hematite	773,666
19	Hawkins	do	Nashwauk	do	720,646
20	Chapin	Michigan	Iron Mountain	do	715,001
21	Shenango	Minnesota	Chisholm	do	699,539
22	Burt	do	Hibbing	do	695,663
23	Plymouth	Michigan	Verona	do	658,297
24	Susquehanna	Minnesota	Hibbing	do	622,051
25	Sauntry-Alpena	do	Virginia	do	605,223
26	Sunrise	Wyoming	Sunrise	do	520,114
27	Palms	Michigan	Bessemer	do	508,723
28	Cornwall	Pennsylvania	Miners Village	Magnetite	491,427
29	Albany	Minnesota	Hibbing	Hematite	460,505
30	Glen	do	Chisholm	do	443,446
31	Montreal	Wisconsin	Montreal	do	441,802
32	Leetonia	Minnesota	Hibbing	do	406,603
33	Commodore	do	Virginia	do	406,369
34	Caspian	Michigan	Palatka	do	404,025
35	Penn group	do	Vulcan and Norway	do	388,771
36	Ordean	Minnesota	Virginia	do	383,968
37	Dunwoody	do	Hibbing	do	372,139
38	Spruce	do	Eveleth	do	369,117
39	Zenith	do	Ely	do	368,453
40	Chisholm	do	Chisholm	do	367,725
41	Corsica	do	Gilbert	do	355,685
42	Chester	do	Chisholm	do	354,979
43	Colby	Michigan	Bessemer	do	344,441

Iron-ore mines of the United States that produced more than 50,000 gross tons each in 1917—Continued.

Rank.	Name of mine.	State.	Nearest town.	Variety of ore.	Quantity mined.
44	Biwabik	Minnesota	Biwabik	Hematite	342,570
45	Stevenson	do	Hibbing	do	342,392
46	Pioneer	do	Ely	do	332,182
47	North Harrison	do	Nashwauk	do	330,777
48	La Rue	do	do	do	319,210
49	Carpenter	Michigan	Crystal Falls	do	318,712
50	Arcturus	Minnesota	Marble	do	314,073
51	Armour No. 2	do	Crosby	do	311,291
52	Hartley-Burt	do	Chisholm	do	310,264
53	Aragon	Michigan	Norway	do	301,934
54	Lake Superior	do	Ishpeming	do	294,449
55	Tobin	do	Crystal Falls	do	293,300
56	Miller	Minnesota	Aurora	do	293,133
57	Lincoln	do	Virginia	do	287,751
58	Songo	Alabama	Songo	do	283,362
59	Clark	Minnesota	Chisholm	do	268,087
60	Woodbridge	do	Buhl	do	267,397
61	Balkan	Michigan	Alpha	do	262,803
62	Pettit	Minnesota	Gilbert	do	262,514
63	Helmer	do	Kinney	do	259,362
64	Webb	do	Hibbing	do	253,802
65	Mohawk	do	Aurora	do	253,609
66	Utica	do	Hibbing	do	251,996
67	Mace No. 2	do	Nashwauk	do	251,280
68	Hill Annex	do	Calumet	do	250,902
69	Cary	Wisconsin	Hurley	do	250,297
70	Aurora	Michigan	Ironwood	do	249,501
71	Smith	Minnesota	Hibbing	do	249,417
72	Puritan	Michigan	Ironwood	do	248,146
73	Tully	do	Stambaugh	do	239,999
74	Graham	Minnesota	Mesaba	do	238,904
75	Ironton	Michigan	Bessemer	do	236,708
76	Philbin	Minnesota	Hibbing	do	230,572
77	Union	do	Virginia	do	221,821
78	Chatham	Michigan	Stambaugh	do	221,378
79	Belgrade	Minnesota	Biwabik	do	219,447
80	Spaulding	Alabama	Birmingham	do	213,968
81	Ottawa	Wisconsin	Montreal	do	211,657
82	Fierro Group	New Mexico	Fierro	Magnetite	208,253
83	Odgers	Michigan	Crystal Falls	Hematite	204,500
84	Section 30	Minnesota	Ely	do	204,497
85	Raimund No. 1	Alabama	Bessemer	do	201,665
86	Bengal	Michigan	Palatka	do	200,572
87	Itasca	Minnesota	Buhl	do	197,481
88	Mahnomen	do	Ironton	do	196,000
89	Sibley	do	Ely	do	193,834
90	Shiras	do	Buhl	do	193,592
91	Kennedy	do	Cuyuna	do	193,409
92	Thompson	do	Crosby	do	191,472
93	Eureka	Michigan	Ramsay	do	191,162
94	Laura	Minnesota	Hibbing	do	190,761
95	Homer	Michigan	Iron River	do	189,872
96	Sunday Lake	do	Wakefield	do	189,212
97	Wanless	Minnesota	Buhl	do	186,721
98	Pewabic	Michigan	Iron Mountain	do	183,414
99	Kinney	Minnesota	Kinney	do	183,314
100	Leonard	do	Chisholm	do	182,336
101	Baltic (Inc. Fogarty)	Michigan	Palatka	do	181,199
102	Cambria	do	Negaunee	do	180,373
103	Genoa	Minnesota	Gilbert	do	171,504
104	Sliver	do	Virginia	do	171,028
105	Mary Charlotte No. 1 and 2	Michigan	Negaunee	do	168,924
106	Hillcrest	Minnesota	Ironton	do	166,350
107	Pennington	do	do	do	165,895
108	North Eddy	do	Hibbing	do	163,974
109	Osana-Wauseca	Michigan	Iron River	do	162,404
110	Bristol	do	Crystal Falls	do	161,000
111	Meacham	Minnesota	Crosby	do	160,108
112	Steinman	Alabama	Steinman	do	159,342
113	St. James	Minnesota	Aurora	do	157,200
114	Brown Mining Co	Tennessee	Cardiff	do	156,924
115	Rowe	Minnesota	Riverton	do	155,874
116	Bangor	do	Biwabik	do	154,379
117	Brunt	do	Mountain Iron	do	151,553
118	Croft	Michigan	Crosby	do	149,898
119	Richmond	do	Palmer	do	149,217
120	Zimmerman	do	Gaastra	do	147,552
121	Loretto	do	Loretto	do	146,687
122	Hiawatha	do	Iron River	do	145,580
123	Soudan	Minnesota	Soudan	do	145,338
124	Mount Hope	New Jersey	Mount Hope	Magnetite	142,799

Iron-ore mines of the United States that produced more than 50,000 gross tons each in 1917—Continued.

Rank.	Name of mine.	State.	Nearest town.	Variety of ore.	Quantity mined.
125	American-Boston	Michigan	Diorite	Hematite	132,422
126	Attalla	Alabama	Attalla	do	128,029
127	North Anvil	Michigan	Bessemer	do	127,937
128	Breitung-Hematite No. 1	do	Negaunee	do	127,588
129	Frantz	Minnesota	Buhl	do	127,245
130	Norman	do	Virginia	do	126,121
131	Hanna A	do	Mountain Iron	do	125,318
132	Washington	New Jersey	Oxford	Magnetite	124,535
133	Geneva	Michigan	Ironwood	Hematite	122,193
134	Tilden	do	Bessemer	do	120,486
135	Mace No. 1	Minnesota	Hibbing	do	119,085
136	Greeley	Alabama	Greeley	Brown ore	119,070
137	South Chandler	Minnesota	Ely	Hematite	117,322
138	Judson	Michigan	Alpha	do	116,523
139	Chandler	Minnesota	Ely	do	116,375
140	Amasa Porter	Michigan	Amasa	do	115,358
141	Agnew	Minnesota	Hibbing	do	115,255
142	Hammond	Alabama	Hammond	do	114,713
143	Bates	Michigan	Iron River	do	113,292
144	Clifford	do	Iron Mountain	do	113,234
145	Midget	Minnesota	Hibbing	do	113,003
146	Majorca	do	Calumet	do	112,394
147	Deacon	do	Buhl	do	111,866
148	Davidson No. 1	Michigan	Iron River	do	110,221
149	Mayville	Wisconsin	Mayville	do	104,212
150	Elba	Minnesota	Gilbert	do	103,068
151	Ohio	Michigan	Michigamme	do	102,665
152	Brotherton	do	Wakefield	do	101,859
153	Hanna B	Minnesota	Mountain Iron	do	101,136
154	Adams	Michigan	Ishpeming	do	99,744
155	Rolling Mill	do	Negaunee	do	96,141
156	Patrick	Minnesota	Nashwauk	do	95,888
157	Asteroid	Michigan	Ramsay	do	94,135
158	Warren	Minnesota	Hibbing	do	94,029
159	Hudson	do	Aurora	do	93,369
160	Grace	do	Hibbing	do	93,022
161	Davidson No. 2	Michigan	Iron River	do	92,048
162	Chicagon	do	do	do	91,445
163	Tioga	Minnesota	Chisholm	do	89,177
164	Bray	do	Keewatin	do	88,843
165	Himrod	Michigan	Negaunee	do	88,447
166	Morrow	Minnesota	Eveleth	do	88,284
167	Richards	Michigan	Crystal Falls	do	86,500
168	Ironaton	Alabama	Ironaton	Brown ore	84,771
169	Ernst	Wisconsin	Commonwealth	Hematite	82,892
170	Rogers	Michigan	Iron River	do	81,958
171	State Lease 40	Minnesota	Crosby	do	81,489
172	Perkins	do	Aurora	do	80,929
173	Oriskany	Virginia	Oriskany	Brown ore	80,791
174	Victoria	Minnesota	Virginia	Hematite	80,710
175	Weed	do	Mesaba	do	80,639
176	Cahoon	Wisconsin	Baraboo	do	80,535
177	Vaney	Alabama	Russellville	Brown ore	78,693
178	Armour No. 1	Minnesota	Crosby	Hematite	77,883
179	Breitung-Hematite No. 2	Michigan	Negaunee	do	77,828
180	Warner	do	Amasa	do	77,592
181	Cuyuna-Duluth	Minnesota	Ironton	do	76,939
182	Jean	do	Eveleth	do	76,663
183	Yale	Michigan	Bessemer	do	73,789
184	Wacootah	Minnesota	Mountain Iron	do	71,807
185	Berkshire	Michigan	Stambaugh	do	71,300
186	Empire	do	Palmer	do	70,931
187	South Uno (N. P.)	Minnesota	Hibbing	do	70,258
188	Thorne	do	Buhl	do	68,962
189	Raimund No. 2	Alabama	Bessemer	do	68,520
190	Isabella	Michigan	Palmer	do	67,341
191	La Belle	Minnesota	Gilbert	do	67,314
192	Queen Group	Michigan	Negaunee	do	67,242
193	North Uno (N. P.)	Minnesota	Hibbing	do	65,151
194	Castile	Michigan	Wakefield	do	64,351
195	Tannehill	Alabama	Goethite	Brown ore	63,786
196	Missabe Mountain	Minnesota	Virginia	Hematite	62,931
197	Friedman	Alabama	Woodstock	Brown ore	61,795
198	Omaha	Minnesota	Brainerd	Hematite	60,000
199	Julia	do	Virginia	do	59,441
200	York	do	Nashwauk	do	58,500
201	Houston	Alabama	Rickey	Brown ore	57,151
202	Anvil	Michigan	Bessemer	Hematite	55,490
203	Cranberry	North Carolina	Cranberry	Magnetite	55,353
204	Wilson, Hyde & Hurst	Alabama	Russellville	Brown ore	54,029
205	Franklin	Minnesota	Virginia	Hematite	53,000

Iron-ore mines of the United States that produced more than 50,000 gross tons each in 1917—Continued.

Rank.	Name of mine.	State.	Nearest town.	Variety of ore.	Quantity mined.
206	Champion	Alabama	Oneonta	Brown ore	51,906
207	Keewanee	do	Birmingham	Hematite	51,532
208	Aad	Minnesota	Eveleth	do	50,889
209	Raimund No. 3	Alabama	Bessemer	do	50,422
210	French Creek	Pennsylvania	St. Peters	Magnetite	50,346
211	Judd	Minnesota	Taconite	Hematite	50,278
212	Madrid	do	Virginia	do	50,000
Total (212 mines)					67,793,451
Unspecified (28 mines)[a]					5,028,722
Output from mines producing more than 50,000 gross tons each					72,822,173
Output from mines producing less than 50,000 gross tons each					2,466,678
Grand total of United States					75,288,851

[a] Includes the product of 28 mines producing more than 50,000 gross tons each and operated by 12 companies which do not permit the publication of individual figures.

STOCK OF IRON ORE AT MINES.

According to the reports of producers, a few of which have been revised since the report for 1916 was published, the total quantity of iron ore in stock at the mines at the close of 1917 amounted to 10,628,908 gross tons, compared with 10,835,224 tons at the close of 1916, a decrease of less than 2 per cent. As the quantity of ore in stock piles is necessarily partly estimated, there are variations in the mine reports from year to year which prevent an absolute balance between the quantity mined and the quantity sold and stocks on hand.

Stock of iron ore at mines, by States, Dec. 31, 1916 and 1917, in gross tons.

State.	1916	1917	State.	1916	1917
Alabama	684,199	619,976	New Mexico		7,700
California	30	14	New York	129,986	61,647
Georgia	10,443	20,654	North Carolina		40
Iowa	1,200	1,200	Ohio	3,388	3,388
Maryland	1,050	2,130	Pennsylvania	36,450	34,961
Massachusetts	4,000	2,950	Tennessee	15,371	128
Michigan	4,671,456	4,840,665	Virginia	41,402	35,931
Minnesota	4,794,561	4,529,733	Wisconsin	289,548	310,557
Missouri	2,913	2,320			
New Jersey	149,227	154,914	Total	10,835,224	10,628,908

PRICES OF IRON ORE PER TON.

In the following table the average selling price per ton at the mines of the different classes of iron ore in 1916 and 1917 is given for each of the producing States or groups of States, except where there were less than three producers or shippers of a certain variety of ore, and permission was not given to publish in a State whose total may be published. The average prices per gross ton (the whole United States considered) in 1917 were: Hematite, $3.12; brown ore, $2.95; and magnetite, $4.29; as compared with prices, respectively, of $2.32, $2.03, and $3.11, in 1916. These figures are taken directly from statements of the producers and probably represent only approximately the actual selling prices. The element of inaccuracy lies in the fact that by far the greater bulk of the iron ore produced in the United States is mined by iron and steel producers for their own furnaces and that the value placed on such ore is therefore largely a matter of accounting. Some of the reports made to the Survey evidently include merely actual mining costs; others contain, in addition, the cost of selling and insuring the ore; in others an allowance for sinking fund is included; and in still others the figures given are the prices used in charging costs against the blast furnaces. At any rate, they include no freight costs. The selling prices of Lake Superior iron ore at lower Lake ports are given on pages 575–576.

The general average price per gross ton of all kinds of iron ore in the United States was $3.15 in 1917, compared with $2.34 in 1916, an increase of 81 cents a ton, or nearly 35 per cent.

Average price per gross ton of iron ore in 1916 and 1917.

State.	Hematite.		Brown ore.		Magnetite.		Carbonate.	
	1916	1917	1916	1917	1916	1917	1916	1917
Alabama	1.52	1.61	1.97	3.08				
California					4.00	4.00		
Georgia	1.32	2.36	1.87	2.58				
Maryland		(a)	(a)	2.56				
Michigan	2.58	3.55						
Minnesota	2.32	3.18						
Missouri	3.58	3.98	2.41	2.27				
New Jersey					3.55	4.93		
New Mexico		2.27			1.07	1.57		
New York	2.09	(a)	(a)	(a)	3.88	5.53		
North Carolina			(a)	2.42	(a)	(a)		
Ohio							[b] 3.00	
Pennsylvania			3.05	4.20	(a)	(a)		
Tennessee	1.42	1.76	1.76	3.01	(a)	(a)		
Virginia	2.06	2.54	2.05	2.49	(a)	(a)		
Wisconsin	2.38	3.32						
Other States [c]	1.00	1.11	3.15	3.54				
Total average	2.32	3.12	2.03	2.95	3.11	4.29	3.00	

[a] Less than three producers or shippers, and permission to publish not given; therefore price may not be shown.

[b] Estimated.

[c] 1916: Colorado, Connecticut, Iowa, Massachusetts, Nevada, Utah, West Virginia, and Wyoming; 1917: Arkansas, Colorado, Connecticut, Iowa, Massachusetts, Montana, Nevada, Utah, West Virginia, and Wyoming.

Average price per gross ton of iron ore in the United States, 1889 and 1892 to 1917.

Year.	Hematite.	Brown ore.	Magnetite.	Carbonate.	General average.
1889					$2.30
1892					2.04
1893					1.66
1894					1.14
1895					1.14
1896					1.42
1897					1.08
1898					1.14
1899					1.42
1900					2.42
1901					1.71
1902					1.84
1903					1.80
1904					1.56
1905					1.77
1906	$2.13	$1.78	$2.05	$1.75	2.11
1907	2.03	1.81	2.03	1.74	2.55
1908	2.32	1.70	2.40	1.38	2.27
1909	2.17	1.68	2.40	1.73	2.15
1910	2.52	1.76	2.36	1.61	2.47
1911	2.12	1.72	2.29	1.83	2.11
1912	1.87	1.79	2.18	1.96	1.88
1913	2.21	1.88	2.07	2.06	2.19
1914	1.79	1.72	2.39	2.44	1.81
1915	1.80	1.80	2.50	2.44	1.83
1916	2.32	2.03	3.11	3.00	2.34
1917	3.12	2.95	4.29		3.15

APPARENT CONSUMPTION OF IRON ORE COMPARED WITH PRODUCTION OF PIG IRON.

The following table includes data on certain items from which an approximate estimate of the annual consumption of iron ore in the United States is deduced. The result is, of course, merely an approximaton, for no data are available on certain items, such as stocks at furnaces, which should enter into the final result. The items considered in the table and in the annual estimates for all years preceding 1911 are (1) domestic iron ore mined; (2) stocks of ore at mines; (3) stocks of ore at lower Lake ports; (4) production of zinc residuum; (5) imports of ore; (6) exports of ore. Beginning with 1911 data on the shipments of ore became available, and these figures, together with zinc residuum and imports of ore, constitute the available supply which, less the exports, gives the apparent domestic consumption, without consideration of the stocks at mines and at Lake ports. This apparent consumption includes small quantities of ore not used in the manfacture of pig iron, such as ore consumed in the open-hearth steel furnaces and in smelting gold, silver, and copper; but it does not include ore used in the manufacture of paint.

In the same table is given the production of pig iron, including ferromanganese, spiegeleisen, ferrosilicon, and other ferroalloys, for corresponding years and the ratio of pig iron and ferroalloys produced to iron ore consumed. On later pages of the report will be found detailed statistics on the production and shipments of pig iron.

The ratio of pig iron manufactured to iron ore consumed was 51.11 per cent in 1917, as compared with 50.42 per cent in 1916.

The actual figures of consumption of ore as reported directly to the Survey by the manufacturers of iron are of interest in comparison with the figures in this table. Prior to 1915 such data have not been sufficiently complete for publication, but in connection with the statistics of value of pig iron, which are collected only by the United States Geological Survey, it has been found necessary to gather related data, some of which are now sufficiently complete for publication. For instance, the quantity of domestic ore consumed in the manufacture of pig iron in 1917, according to reports to the Survey from blast furnaces, was 69,108,181 gross tons; the total consumption of iron ore in 1917, including imported ore and 5,647,723 tons of mill cinder, scale, scrap, etc., was 75,505,078 gross tons, from which were produced 37,924,490 gross tons of pig iron, exclusive of ferroalloys—a ratio of pig iron produced to ore consumed of 50.22 per cent. The quantity of pig iron made in 1917 from domestic ore was 37,364,033 gross tons and from foreign ore 560,457 gross tons. In 1916 the domestic ore consumed was 70,769,337 gross tons, and the total consumption of iron ore, including imported ore and 4,036,022 tons of mill cinder, scale, and scrap, was 76,100,877 gross tons, from which were produced 38,701,963 gross tons of pig iron, exclusive of ferroalloys—a ratio of pig iron produced to ore consumed of 50.86 per cent.

Apparent consumption of iron ore compared with production of pig iron in the United States, 1889–1917, in gross tons.

Year.	Domestic iron ore produced.[a]	Stocks of ore at mines.	Stocks of ore at lower Lake ports Dec. 1.	Zinc residuum.	Imports.	Exports.	Apparent consumption.	Pig iron produced.[b]	Percentage ratio of pig iron to iron ore.
1889	14,518,041	2,256,973	2.607,106	43,648	853,573	....	14,366,562	7,603,642	52.93
1890	16,036,043	2,000,000	3,893,487	48,560	1,246,830	....	16,302,025	9,202,703	56.45
1891	14,591,178	2,450,279	3,508.489	38,228	912,864	....	15,476,989	8,279,870	53.50
1892	16,296,666	2,911,740	4,149,451	31,859	806,585	....	16,032,687	9,157,000	57.11
1833	11,587,629	3,526,161	4,070,710	37,512	526,951	....	11,616,412	7,124,502	61.33
1894	11,879,679	3,236,198	4,834,247	26,981	167,307	....	11,600,393	6,657,388	57.39
1895	15,957,614	2,976,494	4,415,712	43,249	524,153	....	17,203,255	9,446,308	54.91
1896	16,005,449	3,405,302	4,954,984	44,953	682,806	....	15,765,128	8,623,127	54.70
1897	17,518,046	3,098,287	5,923,755	33,924	489,970	....	17,380,184	9,652,680	55.54
1898	19,433,716	2,846,457	5,136,407	48,502	187,208	....	20,708,604	11,773,934	56.86
1899	24,683,173	2,320,278	5,530,283	65,010	674,082	40,665	25,513,903	13,620,703	53,39
1900	27,553,161	3,709,950	5,904,670	87,110	897,831	51,460	26,722,583	13,789,242	51.60
1901	28,887,479	4,239,823	5,859,663	52,311	966,950	64,703	29,357,171	15,878,354	54.09
1902	35.554,135	3,834,717	7,074,254	65,246	1,165,470	88,445	35,886,921	17,821,307	49.66
1903	35,019,308	6,297,888	6,371,085	73,264	980,440	80,611	34,232,399	18,009,252	52.61
1904	27,644.330	4,666,931	5,763,399	68,189	487,613	213,865	30,224,910	16,497,033	54.58
1905	42.526,133	3,812,281	6,438,967	90,289	845,651	208,017	43,433,138	22,992,380	52.94
1906	47,749.728	3,281,789	6,252,455	93,461	1,060,390	265,240	49,355,343	25,307,191	51.28
1907	51,720,619	3,033,110	7,385,728	93,413	1,229,168	278,608	51,879,998	25,781,361	49.69
1908	35.983,336	6,065,397	8,441,533	110,225	776,898	309,099	32,473,268	15,936,018	49.74
1909	51,294,271	6,135,271	8,965,789	141,264	1,694,957	455,934	52,080,428	25,795,471	49.53
1910	57,014,906	9,422,285	9,426,881	137,173	2,591,031	748,875	55,246,129	27,303,567	49.42
1911	41,092,447	....	....	109,296	1,811,732	768,386	42,245,089	23,649,547	55.98
1912	57,017,614	....	....	104,670	2,104,576	1,195,742	58,031,118	29,726,937	51.23
1913	59,643,098	....	....	102,239	2,594,770	1,042,151	61,297,956	30,966,152	50.52
1914	39,714,280	....	....	100,198	1,350,588	551,618	40,613,448	23,332,214	57.45
1915	55,493,100	....	....	159,318	1,341,281	707,641	56,286,058	29,916,213	53.15
1916	77,870,553	....	....	198,817	1,325,736	1,183,952	78,211,154	39,434,797	50.42
1917	75,573,207	....	....	155,332	971,663	1,132,313	75,567,889	38,621,216	51.11

[a] Beginning with 1910, iron ore sold for paint excluded from production and included in metallic paint. Beginning with 1911, figures represent shipments.

[b] From annual reports of the American Iron and Steel Association prior to 1912, and including ferroalloys produced in blast furnaces; beginning with 1912, according to American Iron and Steel Institute, and also including ferroalloys.

IRON-ORE INDUSTRY IN THE LAKE SUPERIOR DISTRICT.

PRODUCTION.

The ranges in the United States portion of the Lake Superior district which produced ore in 1917 were the Marquette, Menominee, Gogebic, Vermilion, Mesabi, and Cuyuna, besides the Baraboo and Iron Ridge areas. Only two of the ranges in the Lake Superior district mined a larger quantity of iron ore in 1917 than in 1916—the Cuyuna and Gogebic ranges—27.7 and 2.3 per cent, respectively. The output of the Cuyuna range approached 2,000,000 tons and for the first time the Cuyuna production surpassed that of the Vermilion range, advancing from sixth to fifth place among the Lake Superior ranges.

The total quantity of ore mined from the Lake Superior district, excluding the Baraboo and Iron Ridge areas, in 1917 was 63,481,321 gross tons, compared with 63,735,088 gross tons in 1916, a decrease of 253,767 tons, or about 0.4 per cent. The output in 1917 excludes all ore containing more than 5 per cent manganese. The Mesabi range mined 41,127,323 tons, compared with 41,325,341 tons in 1916, a decrease of less than 0.5 per cent; the Menominee range, 6,366,483 tons, compared with 6,649,578 tons in 1916, a decrease of 4.3 per cent; the Gogebic range, 7,881,232 tons, compared with 7,707,101 tons in 1916, an increase of 2.3 per cent; the Marquette range, 4,638,374 tons, compared with 4,792,987 tons in 1916, a decrease of 3.2 per cent; the Vermilion range, 1,481,301 tons, compared with 1,704,440 tons in 1916, a decrease of 13.1 per cent; and the Cuyuna range, which in 1917 entered upon its seventh year as a shipper of ore, 1,986,608 tons, compared with 1,555,641 tons in 1916, an increase of 27.7 per cent. The production of maganiferous iron ore from the Cuyuna range is reported in the chapter on manganese and manganiferous ores elsewhere in Mineral Resources for 1917. The Mesabi range produced 64.8 per cent of the entire output of the Lake Superior district and 54.6 per cent of the entire production of the United States.

Iron ore mined in the Lake Superior district,[a] 1916 and 1917, in gross tons.

Range.	1916	1917	Change in 1917.	Per centage of change, 1917.	Percentage of total output, 1917.	
					Lake Superior district.	United States.
Marquette (Michigan)	4,792,987	4,638,374	−154,613	− 3.2	7.3	6.2
Menominee (Michigan and Wisconsin)	6,649,578	6,366,483	−283,095	− 4.3	10.0	8.5
Gogebic (Michigan and Wisconsin)	7,707,101	7,881,232	+174,131	+ 2.3	12.4	10.5
Vermilion (Minnesota)	1,704,440	1,481,301	−223,139	−13.1	2.4	2.0
Mesabi (Minnestoa)	41,325,341	41,127,323	−198,018	− .5	64.8	54.6
Cuyuna (Minnesota)	1,555,641	1,986,608	+430,967	+27.7	3.1	2.6
	63,735,088	63,481,321	−253,767	− .4	100.0	84.4

[a] Includes only such Wisconsin mines as are in the true Lake Superior district.

The following table shows the total production of the Lake Superior district, by ranges. The figures prior to 1872 were collected by A. P. Swineford, editor Marquette Mining Journal [1]; those for 1872 to 1877, inclusive, are from the Michigan Mineral Statistics; those for 1878 to 1888, inclusive, were collected by W. J. Stevens [2]; and the later figures were collected by the United States Geological Survey.

Iron ore produced in the Lake Superior district, 1854–1917, in gross tons.

Year.	Marquette.	Menominee.	Gogebic.	Vermilion.	Mesabi.	Cuyuna.	Total.
1854–1869	3,112,209						3,112,209
1870	859,507						859,507
1871	813,984						813,984
1872	948,553						948,553
1873	1,195,234						1,195,234
1874	899,934						899,934
1875	881,166						881,166
1876	993,311						993,311
1877	1,014,754	10,375					1,025,129
1878	1,033,082	78,028					1,111,110
1879	1,130,019	245,672					1,375,691
1880	1,384,010	524,735					1,908,745
1881	1,579,834	726,671					2,306,505
1882	1,829,394	1,136,018					2,965,412
1883	1,305,364	1,047,863					2,353,227
1884	1,559,912	895,634	1,022	62,122			2,518,690
1885	1,430,862	690,435	119,590	227,075			2,467,962
1886	1,627,383	880,006	756,237	307,948			3,571,574
1887	1,851,717	1,199,343	1,285,265	394,910			4,731,235
1888	1,918,672	1,191,097	1,433,689	511,953			5,055,411
1889	2,631,026	1,876,157	2,147,923	864,508			7,519,614
1890	2,863,848	2,274,192	2,914,081	891,910			8,944,031
1891	2,778,482	1,856,124	2,041,754	945,105			7,621,465
1892	2,848,552	2,402,195	3,058,176	1,226,220	29,245		49,564,388
1893	2,064,827	1,563,049	1,466,815	815,735	684,194		6,594,620
1894	1,935,379	1,255,255	1,523,451	1,055,229	1,913,234		7,682,548
1895	1,982,080	1,794,970	2,625,475	1,027,103	2,839,350		10,268,978
1896	2,418,846	1,763,235	2,100,398	1,200,007	3,082,973		10,566,359
1897	2,673,785	1,767,220	2,163,088	1,381,278	4,220,151		12,205,522
1898	2,987,930	2,275,664	2,552,205	1,125,538	4,837,971		13,779,308
1899	3,634,596	3,281,422	2,725,648	1,643,984	6,517,305		17,802,955
1900	3,945,068	3,680,738	3,104,033	1,675,949	8,158,450		20,564,238
1901	3,597,089	3,697,408	3,041,869	1,805,996	9,303,541		21,445,903
1902	3,734,712	4,421,250	3,683,792	2,057,532	13,080,118		26,977,404
1903	3,686,214	4,093,320	3,422,341	1,918,584	13,452,812		26,573,271
1904	2,465,448	2,871,130	2,132,988	1,056,430	11,672,405		20,198,311
1905	3,772,645	4,472,630	3,344,551	1,578,626	20,156,566		33,325,018
1906	4,070,914	4,962,357	3,484,023	1,794,186	23,564,891		37,876,371
1907	4,167,810	4,779,592	3,609,519	1,724,217	27,245,441		41,526,579
1908	3,309,917	2,904,011	3,241,931	927,206	17,725,014		28,108,079
1909	4,291,967	4,789,362	3,807,157	1,097,444	27,877,705		41,863,635
1910	4,631,427	4,983,729	4,746,818	1,390,360	30,576,409		46,328,743
1911	3,743,145	4,062,778	3,099,197	1,336,938	23,126,943	181,224	35,550,225
1912	3,545,012	4,465,466	3,926,632	1,457,273	32,604,756	369,739	46,368,878
1913	3,977,808	4,997,246	4,743,515	1,536,115	36,378,671	744,007	52,377,362
1914	3,320,763	3,671,499	4,601,240	1,362,416	19,808,434	776,051	33,540,403
1915	3,817,892	4,665,465	4,996,237	1,541,645	30,802,409	1,120,606	46,944,254
1916	4,792,987	6,649,578	7,707,101	1,704,440	41,325,341	1,555,641	63,735,088
1917	4,638,374	6,366,483	7,881,232	1,481,301	41,127,323	1,986,608	63,481,321
	125,697,444	111,269,402	103,488,903	41,128,183	452,111,652	6,733,876	840,429,460

SHIPMENTS AND RECEIPTS.

According to the Iron Trade Review, 64,437,003 gross tons of iron ore were shipped in 1917 from the Lake Superior district, including the Iron Ridge and Baraboo areas in Wisconsin, compared with 66,658,466 tons in 1916. Of the total in 1917, there were 62,498,901 gross tons shipped by boat and 1,938,102 tons by rail, compared with 64,734,198 tons shipped by boat and 1,924,268 tons by rail in 1916. The shipments from the Lake Superior iron-ore ranges and the Baraboo and Iron Ridge areas as reported to the Survey in 1917 amounted to 63,854,752 gross tons, exclusive of manganiferous iron ore containing 5 per cent or more of manganese.

---

[1] U. S. Geol. Survey Mineral Resources, 1882, p. 116, 1883.

[2] Idem, 1891, pp. 39–41, 1893.

Iron ore shipped from the Lake Superior district, 1913–1917, by ports, in gross tons.[a]

Shipping port.	1913	1914	1915	1916	1917
Escanaba, Mich	5,399,444	3,664,451	5,649,289	7,457,444	7,156,854
Marquette, Mich	3,137,617	1,755,726	3,099,589	3,858,092	3,207,145
Ashland, Wis	4,338,230	3,363,419	5,146,772	8,057,814	7,597,841
Two Harbors, Minn	10,075,718	5,610,262	8,642,942	10,735,853	9,990,901
Superior, Wis	13,788,343	11,309,748	8,342,793	12,787,046	13,978,741
Duluth, Minn	12,331,126	6,318,291	15,437,419	21,837,949	20,567,419
Total by lake	49,070,478	32,021,897	46,318,804	64,734,198	62,498,901
Total by rail	876,638	707,829	953,947	1,924,268	1,938,102
	49,947,116	32,729,726	47,272,751	66,658,466	64,437,003

[a] Iron Trade Review.

Iron ore shipped from the Lake Superior district, 1913–1917, by months, in gross tons.[a]

Month.	1913	1914	1915	1916	1917
April	866,387	269,686	503,832	1,658,411	211,532
May	7,284,212	3,832,063	5,012,359	8,449,580	6,283,612
June	7,974,444	5,502,367	6,005,091	9,507,576	9,639,991
July	8,204,416	5,784,514	7,204,020	9,750,157	10,241,633
August	7,684,285	5,869,477	8,081,117	9,850,140	10,146,786
September	7,259,662	5,431,307	7,863,146	9,600,786	9,536,152
October	6,526,103	4,242,392	7,146,873	9,116,196	8,193,892
November	3,270,958	1,068,681	4,445,129	5,715,452	7,333,828
December	18,545	1,411	57,236	1,085,900	911,475
Total by lake[b]	49,070,478	32,021,897	46,318,804	64,734,198	62,498,901
Total by rail	876,638	707,829	953,947	1,924,268	1,938,102
	49,947,116	32,729,726	47,272,751	66,658,466	64,437,003

[a] Iron Trade Review.

[b] Totals by seasons will be found to vary slightly from the sums of the monthly movements because of corrections.

Iron ore received at Lake Erie ports, 1913–1917, in gross tons.[a]

Port.	1913	1914	1915	1916	1917
Toledo	1,084,215	773,711	1,158,374	2,035,160	2,445,602
Huron	687,485	617,363	695,865	1,324,112	1,631,395
Lorain	3,709,213	1,677,988	3,517,258	4,613,929	3,831,244
Cleveland	8,812,583	5,519,698	7,504,697	10,669,745	9,077,161
Fairport	2,037,126	1,558,134	2,001,103	2,580,647	2,311,179
Ashtabula	8,336,126	5,318,788	7,813,101	11,474,268	10,251,304
Conneaut	7,849,303	6,263,480	8,573,509	9,588,341	8,729,754
Erie	713,904	260,991	707,875	1,525,031	2,079,227
Buffalo	5,506,691	2,913,273	5,339,724	7,432,220	7,843,215
Detroit	363,001	332,564	459,877	425,579	418,151
Port Colborne, Ontario, Canada	....	166,665	196,077	138,240	194,627
	39,099,647	25,402,655	37,967,460	51,807,272	48,812,859

[a] Iron Trade Review.

The difference between the shipments of Lake Superior ore and the receipts of Lake Erie ports is accounted for in large part by the quantity of ore delivered at Lake Michigan ports, South Chicago, Ill., Gary and Indiana Harbor, Ind., and Milwaukee, Wis., the receipts at those ports and at smaller places being shown in the table following. It is understood that there is also a loss, probably less than 1 per cent, in handling ore between mines and lower Lake ports.

Iron ore received at Lake Michigan ports, 1913–1917, in gross tons.[a]

Port.	1913	1914	1915	1916	1917
Elk Rapids, Mich	....	28.437	....	....	....
East Jordan, Mich	28,444	38,158	37,658	38,573	35,792
Milwaukee, Wis	234,591	93,121	187,286	239,219	224,570
Gary, Ind	2,365,551	1,631,564	2,421,924	2,718,185	3,883,082
Indiana Harbor, Ind	455.252	661,054	689,226	793,215	900,692
South Chicago, Ill	5,572,866	3,606,587	4,195,976	7,740,877	7,030,174
Boyne City, Mich	45.028	50,098	40,401	43,788	44,437
	8,701,732	6.109,019	7,572,471	11,573,857	12,118,747

[a] Iron Trade Review.

The following table shows the total quantity of iron ore shipped from the Lake Superior district since 1854, the date of the opening of the Marquette range, the oldest of the Lake Superior ranges. This table gives the shipments as published by the Iron Trade Review and is inserted for comparison with the table giving the total production of the Lake Superior district, without regard to shipments.

Iron ore shipped from the Lake Superior district, 1854–1917, in gross tons.[a]

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1854	3,000	1876	992,764	1898	14,024,673
1855	1,449	1877	1,015,087	1899	18,251,804
1856	36,343	1878	1,111,110	1900	19,059,393
1857	25,646	1879	1,375,691	1901	20,589,237
1858	15,876	1880	1,908,745	1902	27,571,121
1859	68,832	1881	2,306,505	1903	24,289,878
1860	114,401	1882	2,965,412	1904	21,822,839
1861	49,909	1883	2,353,288	1905	34,384,116
1862	124,169	1884	2,518,692	1906	38,565,762
1863	203,055	1885	2,466,372	1907	42,266,668
1864	243,127	1886	3,568,022	1908	25,014,987
1865	236,208	1887	4,730,577	1909	42,586,869
1866	278,796	1888	5,063,693	1910	43,442,397
1867	473,567	1889	7,292,754	1911	32,793,130
1868	491,449	1890	9,012,379	1912	48,221,546
1869	617,444	1891	7,062,233	1913	49,947,116
1870	830,940	1892	9,069,556	1914	32,729,726
1871	779,607	1893	6,060,492	1915	47,272,751
1872	900,901	1894	7,748,932	1916	66,658,466
1873	1,162,458	1895	10,429,037	1917	64,437,003
1874	919,557	1896	9,934,828		
1875	891,257	1897	12,469,638		834,853,280

[a] Iron Trade Review.

STOCKS OF IRON ORE AT LAKE ERIE PORTS.

Stocks of iron ore at Lake Erie ports, Dec. 1, 1913–1917, in gross tons.[a]

Port.	At close of navigation, Dec. 1—				
	1913	1914	1915	1916	1917
Toledo, Ohio	349,047	580,600	311,799	394,869	399,479
Sandusky, Ohio	2,472	2,471	1,871	....	....
Huron, Ohio	441,541	483,769	558,692	590,743	556,765
Lorain, Ohio	694,704	548,097	824,988	1,076,105	978,108
Cleveland, Ohio	1,930,720	1,757,543	1,795,962	1,936,906	1,914,071
Fairport, Ohio	478,014	406,124	413,994	474,930	536,580
Ashtabula, Ohio	3,202,807	2,749,315	2,870,204	3,266,752	3,435,624
Conneaut, Ohio	1,248,032	1,160,639	1,216,686	1,363,550	1,544,706
Erie, Pa	594,613	484,467	589,355	625,193	519,698
Buffalo, N. Y	319,726	234,880	326,800	438,712	441,318
	9,261,676	8,407,905	8,910,351	10,167,760	10,326,349

[a] Iron Trade Review.

Stocks of iron ore at Lake Erie ports May 1, 1914–1918, in gross tons.[a]

Port.	At opening of navigation, May 1—				
	1914	1915	1916	1917	1918
Toledo, Ohio	215,534	255,343	164,637	257,030	230,797
Sandusky, Ohio	2,741	2,471	....	....	....
Huron, Ohio	308,478	462,917	286,054	333,124	387,042
Lorain, Ohio	245,057	377,550	173,771	503,618	475,137
Cleveland, Ohio	1,487,292	1,592,783	772,721	970,973	933,687
Fairport, Ohio	245,038	283,591	198,636	237,645	329,528
Ashtabula, Ohio	2,187,622	1,963,233	1,176,142	1,660,818	1,744,448
Conneaut, Ohio	495,153	564,077	41,080	183,255	844,447
Erie, Pa	461,750	412,186	342,866	406,078	363,008
Buffalo, N. Y	271,492	178,152	187,498	219,691	313,925
	5,920,157	6,092,303	3,343,405	4,772,232	5,622,019

[a] Marine Review.

PRICES OF LAKE SUPERIOR IRON ORE.

Beginning with the season of 1907 the base for the old range and Mesabi Bessemer ore has been a metallic iron content of 55 per cent natural, and that of the old range and Mesabi non-Bessemer ore has been a metallic iron content of 51.5 per cent natural. For the years preceding 1907 the guaranty of Bessemer ores was 55.70 per cent iron natural, and for the non-Bessemer ores it was 52.80 per cent, except Mesabi non-Bessemer for 1905 and 1906, when the natural iron content was 53 per cent.

At Lake Erie ports for the season of 1917 and the first half of 1918 Mesabi Bessemer was listed at $5.70 a gross ton and Mesabi non-Bessemer at $5.05 a ton, compared with $4.20 and $3.55 a ton, respectively, for 1916; old range Bessemer was listed at $5.95 and old range non-Bessemer at $5.20 a ton for 1917, compared with $4.45 and $3.70 a ton, respectively, for 1916. These prices represent advances of $1.50 a ton on all grades of ore, or from 34 per cent to 42 per cent. These advances, though considerable, are not proportionate to the advances in the prices of pig iron during the corresponding period (which averaged at the furnaces nearly 61 per cent), and iron ore producers succeeded in obtaining Government approval of an increase of 45 cents a ton on all grades of ore on July 1, 1918, and of 25 cents more, effective October 1, 1918.

Selling prices of iron ore per gross tons at lower Lake ports at date of buying movement, 1890–1918.[a]

Season.	Date of buying movement.	Season iron-ore prices.			
		Old range Bessemer.	Mesabi Bessemer.	Old range non-Bessemer.	Mesabi non-Bessemer.
1890	Dec. 15, 1889	$5.50	No sale.	$5.25	No sale.
1891	June 1, 1891	4.50	No sale.	4.25	No sale.
1892	Jan. 31, 1892	4.50	No sale.	3.65	No sale.
1893	Mar. 15, 1893	3.85	$3.00	3.20	No sale.
1894	Mar. 1, 1894	2.75	2.35	2.50	No sale.
1895	Apr. 1, 1895	2.90	2.15	2.25	$1.90
1896	May 1, 1896	4.00	3.50	2.70	2.25
1897	May 20, 1897	2.60	2.25	2.15	1.90
1898	Mar. 20, 1898	2.75	2.25	1.85	1.75
1899	Feb. 1, 1899	3.00	2.40	2.15	2.00
1900	Dec. 15, 1899	5.50	4.50	4.25	4.00
1901	Apr. 15, 1901	4.25	3.25	3.00	2.75
1902	Feb. 1, 1902	4.25	3.25	3.25	2.75
1903	Mar. 20, 1903	4.50	4.00	3.60	3.20
1904	Apr. 15, 1904	3.25	3.00	2.75	2.50
1905	Feb. 1, 1905	3.75	3.50	3.20	3.00
1906	Dec. 5, 1905	4.25	4.00	3.70	3.50
1907	Nov. 5, 1906	5.00	4.75	4.20	4.00
1908	June 15, 1908	4.50	4.25	3.70	3.50
1909	May 10, 1909	4.50	4.25	3.70	3.50
1910	Dec. 24, 1909	5.00	4.75	4.20	4.00
1911	Apr. 21, 1911	4.50	4.25	3.70	3.50
1912	Mar. 20, 1912	3.75	3.50	3.00	2.85
1913	Nov. 19, 1912	4.40	4.15	3.60	3.40
1914	May 1, 1914	3.75	3.50	3.00	2.85
1915	Apr. 19, 1915	3.75	3.45	3.00	2.80
1916	Dec. 7, 1915	4.45	4.20	3.70	3.55
1917	Nov. 22, 1916	5.95	5.70	5.20	5.05
1918[b]	Apr. 1, 1918	5.95	5.70	5.20	5.05
	July 1, 1918	6.40	6.15	5.65	5.50
	Oct. 1, 1918	6.65	6.40	5.90	5.75

[a] Iron Trade Review.

[b] Prices approved by the Government Apr. 1, were advanced 45 cents for all grades on July 1, and 25 cents more on Oct. 1.

MINING DEVELOPMENTS.

In a comprehensive review of the mining developments and conditions in the Lake Superior district, particularly the Minnesota ranges, for the year 1917, by Sawhill,[1] it is indicated that exploration and development work in this district has uncovered sufficient ore nearly to match the record shipments of this and the preceding year. In this article it is pointed out that no public campaign was necessary in order to stimulate the production of iron ore to meet the war demand and that there was every reason to believe that the Lake Superior district would be able to continue to meet that demand, should it be necessary, throughout 1918. Transportation agencies were handicapped to a greater degree in 1917 than in the preceding year by inclement weather, ice, and shortage of boats, but, as indicated on page 573, the Lake shipments fell off only about 2,235,000 tons.

---

[1] Sawhill, R. V., How ore districts meet war demand: Iron Trade Rev., Jan. 3, 1918, pp. 85–94, 108.

Shipments of iron ore from mines to furnaces entirely by rail, notwithstanding prophesies to the contrary, showed only a small increase—less than 14,000 tons—and amounted to less than 2,000,000 gross tons in all. Some of this ore was shipped to blast furnaces at St. Louis, Mo. An interesting development in this connection is the transportation in 1917 of about 3,000 tons of ore by barge down Mississippi River from St. Paul, Minn., to St. Louis, Mo. Such navigation is possible from March to November, inclusive, and it is expected that the quantity of ore so carried will increase and that it will also include ore mined at Waukon, Iowa.

Development of labor-saving equipment has become an important feature of iron-ore mining in the Lake Superior district, and has been stimulated by the shortage of labor coupled with the necessity of getting out extraordinary quantities of ore in 1916 and 1917. Mammoth steam shovels are increasing in number; pneumatically operated 20-ton steel ore cars are being substituted for hand-operated 7-ton wooden cars, and heavier locomotives also are used; dirt spreaders and track layers dispense with gangs of laborers; drag-line excavators are coming into use as well as skip hoists; ore loaders for underground mines are being developed; and mining equipment is being electrified.

Ore concentration, especially of the lean ores of the western part of the Mesabi range, continued to make progress. Three new washing plants are reported to have been completed in 1917; three more were under construction, besides six plants already in operation. Screens especially developed for rock separation were installed at three mines.

At the beginning of 1917 there was considerable uncertainty as to whether labor conditions might be such as to interfere seriously with mining and shipment of the required quantity of iron ore, because in 1916 there had been considerable unrest and some strikes due to agitation by outside influences. During 1917, however, the unrest subsided to a great extent, the high wages contributing in no small measure to this result. Two wage increases were made during 1917, one on May 1 and another on October 1, so that common labor received at the close of the year $3.45 per day and contract miners earned in many instances in excess of $4.75 per day. The following table [1] indicates the advance in wages during the last two years:

Wages in iron mines of Lake Superior district, 1915–1917.

Kind of labor.	Daily wages.				
	1915 (Dec. 1).	1916		1917	
		Dec. 1.	Dec. 15.	May 1.	Oct. 1.
Common labor	$2.25	$2.60	$2.85	$3.15	$3.45
Common labor (company account)	2.60	2.90–3.00	3.20–3.30	3.40–3.50	3.70–4.00
Miners (contract)	2.75–2.85	3.50	3.85	4.25	4.70–4.75

---

[1] Iron Trade Rev., Jan. 3, 1918, p. 92.

Notwithstanding these very liberal wages labor is generally considered to be less efficient than in the days of greater competition and more moderate wages.

The shortage of labor was accented to some extent by the Nation's call to war service, for there was a patriotic response in the way of enlistments and many men were drafted, but the inroads upon the mining organizations were not as great proportionately as in many other industries on account of the large alien population in the iron-ore districts.

IRON-ORE RESERVES.

In view of the heavy draft on ore reserves since the beginning of the European war a comparison of tonnage estimates at different periods is of interest. Data are available for the reserves in Minnesota and in Michigan, but not for Wisconsin. The ore reserves of Wisconsin are, however, much smaller than those of the other two States. The estimates of ore reserves in Minnesota were prepared by the Minnesota Tax Commission, and those for Michigan by R. C. Allen, State geologist. The figures given in the following tables include developed and prospective ore in the ground and ore in stock piles.

Iron-ore reserves in Minnesota May 1, 1915, 1916, and 1917, in gross tons.

Range.	1915.	1916.	1917.
Mesabi	1,389,003,652	1,384,635,891	1,381,674,246
Vermilion	11,011,974	13,058,280	11,961,684
Cuyuna	72,403,065	77,926,062	69,915,118
	1,472,418,691	1,475,620,233	1,463,551,048

Iron-ore reserves in Michigan Jan. 1, 1916, 1917, and 1918, in gross tons.

Range.	1916.	1917.	1918.
Gogebic	45,932,974	47,317,323	55,813,661
Marquette	82,562,079	95,751,569	78,175,301
Menominee (including Iron River and Crystal Falls districts)	70,525,437	69,708,894	66,154,547
	199,020,490	212,777,776	200,143,509

The data for Minnesota and Michigan are not based on the same dates and are therefore not strictly comparable, but they show the trend of the balance between production and ore believed to be in reserve. In Minnesota the blocking out of new ore reserves during the year ending May 1, 1916, apparently more than kept pace with the depletion of the supplies, but during the next year there was an apparent falling off of more than 12,000,000 tons. This decrease, however, was largely due to revisions of earlier estimates of reserves on the Cuyuna range. In Michigan during the year ending January 1, 1917, exploration kept ahead of production, but on January 1, 1918, there appears to have been a decrease in the reserves of more than 12,600,000 gross tons, or about 70 per cent of the quantity mined in that State in 1917.

FOREIGN TRADE IN IRON ORE.

IMPORTS.

The quantity of iron ore imported into the United States in 1917 was 971,663 gross tons, valued at $3,655,392, or $3.76 a ton. This represents a decrease in quantity of 354,073 tons, or nearly 27 per cent, and in value of $911,122, or nearly 20 per cent, as compared with the imports during 1916, which were 1,325,736 gross tons, valued at $4,566,514, or $3.44 a ton. As to the source of the imports in 1917, Cuba produced more than 56 per cent of the ore, Canada 20 per cent, Spain 16 per cent, Sweden 6 per cent, and minor quantities came from French Africa and the United Kingdom. Supplies from Canada have increased since 1914, largely from the Canadian ranges in the Lake Superior region. The diagram (fig. 7), indicates the source and destination of the iron ore imported into the United States.

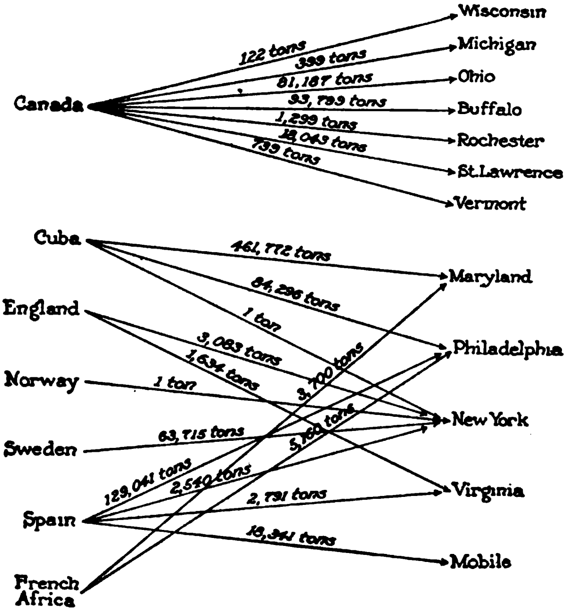

Canada
122 tons
399 tons
81,187 tons
93,799 tons
1,299 tons
18,043 tons
739 tons
Wisconsin
Michigan
Ohio
Buffalo
Rochester
St. Lawrence
Vermont
Cuba
England
Norway
Sweden
Spain
French Africa
461,772 tons
84,296 tons
1 ton
3,083 tons
1,634 tons
1 ton
3,700 tons
63,715 tons
5,160 tons
129,041 tons
2,540 tons
2,791 tons
18,341 tons
Maryland
Philadelphia
New York
Virginia
Mobile

FIGURE 7.—Source and destination of iron ore imported into the United States in 1917.

The statistics of imports of iron ore are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Iron ore imported into the United States, 1914–1917.

Country.	1914		1915		1916		1917	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Cuba	815,017	$2,288,102	831,618	$2,450,163	715,571	$2,195,409	546,069	$1,728,437
Spain	66,982	233,287	42,092	165,827	161,422	582,691	152,713	582,644
French Africa	46,175	114,781	21,825	47,272	38,004	95,342	8,860	22,212
Greece	....	....	738	2,895	....	....	....	....
Newfoundland and Labrador	38,515	57,681	....	....	....	....	....	....
United Kingdom	2,663	52,814	....	....	140	2,019	4,717	133,004
Germany	2,256	9,222	....	....	....	....	....	....
Canada	52,514	158,415	84,124	245,092	136,835	509,572	195,588	850,153
Belgium	....	....	....	....	....	....	....	....
Sweden	280,887	1,481,747	204,632	1,061,624	212,063	1,108,216	63,715	338,936
Chile	35,180	41,760	153,600	181,271	71,701	73,265	....	....
Other countries	[a] 10,399	[a] 51,023	[b] 2,652	[b] 27,501	....	....	[c] 1	6
	1,350,588	4,483,832	1,341,281	4,181,645	1,325,736	4,566,514	971,663	3,655,392

[a] Of this, 2,400 tons, valued at $3,600, was from Venezuela, and 6,050 tons, valued at $40,039, was from French Oceania.

[b] Of this, 2,638 tons, valued at $27,280, was from Egypt.

[c] Norway.

In the following table are shown the annual imports of iron ore into the United States as far as recorded. Iron ore was imported from Europe in large quantities for the first time in 1879, most of the imports prior to that date coming from Canada.

Iron ore imported into the United States, 1872–1917, in gross tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1872	23,733	1888	587,470	1905	845,651
1873	45,981	1889	853,573	1906	1,060,390
1874	57,987	1890	1,246,830	1907	1,229,168
1875	56,655	1891	912,864	1908	776,898
1876	17,284	1892	806,585	1909	1,694,957
1877	30,669	1893	526,951	1910	2,591,031
1878	28,212	1894	167,307	1911	1,811,732
1879[a]	150,197	1895	524,153	1912	2,104,576
1879[b]	284,141	1896	682,806	1913	2,594,770
1880	493,408	1897	489,970	1914	1,350,588
1881	782,887	1898	187,208	1915	1,341,281
1882	589,655	1899	674,082	1916	1,325,736
1883	490,875	1900	897,831	1917	971,663
1884	487,820	1901	966,950		
1885	390,786	1902	1,165,470		38,020,568
1886	1,039,433	1903	980,440		
1887	1,194,301	1904	487,613		

[a] Fiscal years end. [b] Calendar years begin.

EXPORTS.

The quantity of iron ore exported from the United States in 1917 amounted to 1,132,313 gross tons, valued at $4,464,111, or $3.94 a ton, as compared with 1,183,952 gross tons, valued at $3,702,496, or $3.13 a ton, in 1916. This represents a decrease in quantity of 51,639 tons, or 4 per cent, and an increase in value of $761,615, or 20 per cent. The greater part of the ore was exported to Canada, it is understood, for the manufacture of iron and steel at plants in Ontario. More ore was exported to Canada in 1917 than was imported into the United States from all sources.

The data regarding exports are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Iron ore exported from the United States, 1916–1917.

Country	1916		1917	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
England	5	$300	45	$1,359
Canada	1,183,679	3,699,727	1,129,390	4,451,240
Brazil	100	605	....	....
Chile	168	1,864	....	....
Mexico	....	....	2,878	11,512
	1,183,952	3,702,496	1,132,313	4,464,111

Iron ore exported from the United States, 1899–1917, in gross tons.

Year.	Quantity.	Year.	Quantity.
1899	40,665	1909	455,934
1900	51,460	1910	748,875
1901	64,793	1911	768,386
1902	88,445	1912	1,195,742
1903	80,611	1913	1,042,151
1904	213,865	1914	551,618
1905	208,017	1915	707,641
1906	265,240	1916	1,183,952
1907	278,608	1917	1,132,313
1908	309,099		
			9,387,325

IRON-ORE INDUSTRY OF CUBA.

The iron ore shipped from Cuba to the United States in 1917 amounted to 553,485 gross tons, valued at $2,793,113, compared with 712,716 gross tons, valued at $2,196,327, in 1916, a decrease in quantity of 159,231 tons, or 22 per cent, and an increase in value of $596,786, or 27 per cent. The average selling price of the ore was apparently $5.05 a ton in 1917, compared with $3.08 in 1916. The shipments in 1917 consisted of 48 per cent of hematite, including a little magnetite, from the Daiquiri, Juragua, and Cuero mines on the southern coast, and 52 per cent of brown ore from the Mayari mines, near the northern coast. In 1916 the iron content of the hematite, dried at 212° F., ranged from 57 per cent to 60.03 per cent, and the brown ore carried 35.22 per cent (natural) and 52.44 per cent (nodulized), and in 1917, hematite (natural) ranged from 55.67 per cent to 58.61 per cent, with one report of dried ore that carried 58.81 per cent, and the brown ore carried 35.05 per cent (natural) and 54.23 per cent (nodulized). The product of the Cuero mines is noted as a low-phosphorus ore. The total stock of ore reported as on hand at the close of 1917 was 1,166,934 gross tons, compared with 628,120 tons at the close of 1916. This included both natural and nodulized ore.

The following table shows the shipments of iron ore from Cuba since the opening of the mines in 1884. The curtailment of iron-ore production in Cuba as a result of the war in Europe is shown by these statistics. The sudden depression in the iron industry in 1914 reduced the Cuban ore output about 48 per cent as compared with 1913. In 1915 the output was about the same as in 1914, but in 1916 and 1917 the output was further restricted by the shortage of ships, notwithstanding the great need for these excellent and easily accessible ores at iron and steel plants on the eastern seaboard of the United States. The statistics of the Cuban iron-ore shipments are collected by the United States Geological Survey.

Iron ore shipped from mines in the Province of Oriente, Cuba, 1884–1917, in gross tons.

Year.	Juragua Iron Co. (Ltd.) (hematite and magnetite).	Sigua Iron Co. (hematite).	Spanish-American Iron Co.		Cuban Steel Ore Co. (hematite).	Ponupo Manganese Co., El Cuero iron mines (hematite).	Total.
			Daiquiri mines (hematite and a little magnetite).	Mayari mines (brown ore).			
1884	25,295						25,295
1885	80,716						80,716
1886	112,074						112,074
1887	94,240						94,240
1888	206,061						206,061
1889	260,291						260,291
1890	363,842						363,842
1891	264,262						264,262
1892	335,236	6,418					341,654
1893	337,155	14,020					351,175
1894	156,826						156,826
1895	307,503		74,991				382,494
1896	298,885		114,110				412,995
1897	[a] 248,256		[b] 206,029				454,285
1898	83,696		80,225				163,921
1899	161,783		211,442				373,225
1900	154,871		293,195				448,066
1901	199,764		[c] 334,974		17,651		552,389
1902	221,039		455,105		23,590		699,734
1903	155,898		467,629				623,527
1904	31,162		356,111				387,273
1905	139,828		421,331				561,159
1906	133,379		507,195				640,574
1907	181,063		469,111				650,174
1908	366,580		254,256				620,836
1909	356,659		519,752			59,721	936,132
1910	318,814		670,976	307,700		165,008	1,462,498
1911	355,132		252,717	387,791		168,074	1,163,714
1912	360,094		463,533	446,176		127,994	1,397,797
1913	369,213		591,322	491,713		130,183	1,582,431
1914	267,641		284,507	228,949		40,013	821,110
1915	215,032		245,590	300,896		65,930	827,448
1916	212,013		181,602	258,451		60,650	712,716
1917	39,784		181,028	287,904		44,769	553,485
	7,414,087	20,438	7,636,731	2,709,580	41,241	862,342	18,684,419

[a] Of this quantity, 5,932 tons were sent to Pictou, Nova Scotia.
[b] Of this quantity, 51,537 tons were sent to foreign ports.
[c] Of this quantity, 12,691 tons were sent to foreign ports.

PRODUCTION OF IRON ORE IN PRINCIPAL COUNTRIES.

Since the beginning of the war in Europe authentic statistics of iron ore output from most of the principal producing foreign countries have not been available, and in the chapter on iron ore in mineral resources for 1916 no table of production in principal countries was given. The greater importance that has become attached to foreign statistics and their interpretation since the United States became involved in the war has made it especially desirable to present once more as many of these figures as possible. The following table has been prepared from many more sources of information than were formerly utilized; consequently the data are not so uniform and in all probability are not so reliable as those obtained in times of peace directly from the governments concerned. Though the statistics are far from complete, and many of the figures are subject to revision, it is believed that the table will serve a useful purpose.

Iron ore produced in some principal countries, 1913-1917, in gross tons.

Country.	1913	1914	1915	1916	1917	Source of data.[a]
North America:						
Canada [b]	274,673	218,620	355,457	245,693	192,210	1913-1917, 1.
Cuba [b]	1,582,431	821,110	827.448	712,716	553,485	1913-1917, 2.
Newfoundland [b]	1,433,858	566,000	775,403	903,625	788,820	1913-1917, 1.
United States	61,980,437	41,439,761	55,526,490	75,167,672	75,288,851	1913-1917, 2.
South America:						
Chile [c]	13,877	62,484	153,600	61,701	....	1913-14, 3; 1915-16, 4.
Venezuela [d]	57,225	2,400	(e)	(e)	(e)	1913-14, 4.
Europe:						
Austria-Hungary	5,233,055	3,939,248	[f]1,218,367	(e)	(e)	1913-1915, 5.
Belgium	147,048	(e)	(e)	(e)	(e)	1913, 5.
France	21,572,835	(e)	(e)	(e)	(e)	1913, 4.
Germany	28,771,598	(e)	(e)	(e)	(e)	1913, 4.
Greece	305,095	294,476	154,900	83,619	(e)	1913-1915, 5; 1916, 3.
Italy	593,618	695,124	669,042	927,101	[g]516,070	1913-14, 4; 1915-16, 5; 1917, 6.
Luxemburg	7,215,514	4,926,980	6,040,765	6,643,689	4,436,682	1913-1917, 5.
Norway	77,667	641,790	706,379	865,700	(e)	1913-1916, 5.
Portugal	48,392	6,532	(e)	(e)	(e)	1913-14, 5.
Russia	7,947,191	(e)	(e)	(e)	(e)	1913, 5.
Spain	9,703,177	6,710,357	5,527,552	5,762,733	5,461,857	1913-1916,5 ; 1917, 7.
Sweden	7,355,428	6,480,773	6,772,683	6,874,018	(e)	1913-1916, 5.
United Kingdom	15,997,328	14,867,582	14,235,012	13,494,658	15,180,000	1913-1916, 8; 1917, 5.
Asia:						
China	[h]416,342	[h]488,258	537,047	274,078	299,405	1913-14, 9; 1915-1917, 5.
Chosen (Korea)	139,730	179,062	206,510	241,412	(e)	1913-1916, 10.
India	370,845	441,674	390,270	411,758	(e)	1913-1916, 5.
Japan	168,897	134,193	133,933	156,263	(e)	1913-1916, 10.
Philippine Islands	546	392	(e)	(e)	(e)	1913-14, 11.
Africa:						
Algeria	1,327,320	1,097,101	805,547	923,598	(e)	1913-1916, 5.
Morocco	....	....	186,149	(e)	(e)	1915, 5.
Tunis	584,649	244,528	281,304	361,593	596,261	1913-1917, 5.
Australia	[i]90,712	177,938	370,887	390,108	[j]328,310	1913, 4; 1914-1916, 5; 1917, 3.

[a] 1, Canada Department of Mines, Mines Branch; 2, United States Geological Survey; 3, Mineral Industry; 4, United States Geological Survey Mineral Resources; 5, Iron, Steel and Allied Trades Federation (London) Statistical Report 3; 6, La Metallurgia Italiana, Sept. 1, 1917; 7, Engineering and Mining Journal, Nov. 9, 1918, p. 840; 8, Mines and Quarries (London); 9, Iron Trade Review, July 26, 1917; 10, Bureau of Foreign and Domestic Commerce, Department of Commerce; 11, Bureau of Mines, Manila, P. I.

[b] Shipments.

[c] Exports.

[d] Exports to United States.

[e] Statistics not available.

[f] For Hungary only.

[g] 6 months only.

[h] From Tayeh deposits only.

[i] For South Australia and Queensland.

[j] For South Australia only.

BENEFICIATED IRON ORE.

Statistics of beneficiated iron ore have been gathered by the Survey for the years beginning with 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting and have shown continued improvement.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 94 mines in 16 States in 1917 and at 83 mines in 14 States in 1916, and in addition at the brown-ore mines of the Spanish-American Iron Co. in the Mayari district, Cuba.

In addition to these processes some iron ore is recovered in the form of blast-furnace ore dust, but no statistics have been gathered on this subject. Ore so recovered has been originally accounted for in the statistics of shipments from the mines. Operations which involve sintering of the ore dust have been carried on by the Sintered Ore Co., at Buffalo, N. Y., and the American Sintering Co., at Youngstown, Ohio.

In Alabama the ore treated was principally brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total of 1,159,624 gross tons of beneficiated ore, valued at $3,324,715, was marketed from 19 mines in Alabama in 1917, compared with 996,344 tons, valued at $1,969,706, from 12 mines in 1916. Of this quantity 242,742 tons were hematite run over a picking belt.

One mine in Connecticut, 10 in Georgia, 1 in Iowa, 1 in Maryland, 1 in Massachusetts, and 1 in Missouri reported the concentration of brown ore in 1917.

Red hematite was beneficiated at 2 mines in Michigan and at 18 mines in Minnesota in 1917. Washing and drying were the principal processes employed, and 1 mine reported crushing and picking also in 1917.

Five mines reported magnetic concentration of magnetite in New Jersey, and at 2 of them dry tables were employed in addition; 2 mines reported hand cobbing. At 1 mine in North Carolina, which produces magnetite, the ore was subjected to a rough concentration consisting of electromagnetic cobbing, and 2 mines reported washing of brown ore in 1917.

In New York beneficiation of ore was reported by 10 mines. One mine crushed washed brown ore; and the rest produced magnetite. The magnetite was mainly concentrated magnetically, although at one mine only crushing and hand picking on slow-moving belt were reported. The total shipments of beneficiated brown ore and magnetite in New York amounted to 958,979 gross tons, valued at $5,446,881, in 1917, compared with 1,042,823 tons, valued at $4,104,398, in 1916. At the Waukon, Iowa, brown-ore mine there was a large increase in production, the shipments of beneficiated ore having amounted in 1917 to 22,612 gross tons compared with 10,151 gross tons in 1916, an increase of more than 122 per cent. The product was shipped to the furnace of the Mississippi Valley Iron Co. at St. Louis, the owner of the mine.

In Pennsylvania 2 mines reported washing brown ore; at 1 mine the Grondal concentrating process was employed; 1 magnetite mine reported desulphurization by sintering. The shipments of beneficiated ore from this State amounted to 215,380 gross tons, valued at $1,031,296, in 1917, compared with 208,351 tons, valued at $776,830, in 1916.

In Tennessee red hematite from the mines of the Rockwood-Cardiff area was improved by breaking and hand picking, and brown ore from 7 mines in the west-central belt was beneficiated. At six of these brown-ore mines washing was reported as the only method;

the other reported hand picking, washing, and jigging. In all probability, however, hand picking is employed to a greater or less extent at nearly all brown-ore mines where the ore occurs with gravel. Calcining of brown ore is practiced at one cold-blast furnace. The total beneficiated iron ore shipped from mines in Tennessee in 1917 was 334,254 gross tons, valued at $739,505, compared with 331,499 tons, valued at $533,266, in 1916. One magnetite mine reported hand picking.

Six mines reported beneficiation of brown ore in Virginia in 1917, compared with seven in 1916. The total shipments of treated ore in 1917 amounted to 134,215 gross tons, valued at $350,203, compared with 155,436 tons, valued at $307,653, in 1916. A small quantity of magnetite was also treated at one of these mines. Washing, screening, and jigging were the methods employed in treating the brown ore.

The brown ores of the Mayari mines, Cuba, have been nodulized for many years at an extensive plant at Felton, on Nipe Bay. The total quantity of this ore reported as shipped in 1917 amounted to 285,724 gross tons, compared with 257,605 tons in 1916.

The total beneficiated ore reported as shipped from mines in the United States in 1917 amounted to 8,166,564 gross tons, valued at $27,733,036, compared with 8,105,011 tons, valued at $21,037,364, in 1916. This represents an increase in quantity of 61,553 tons, or about 0.76 per cent. From such figures as are available, showing the relation between crude ore treated and beneficiated ore recovered, it is apparent that in washing brown ore the ratios, by weight, of crude ore washed to resultant concentrates range from 7:1 to 1.24:1; in concentrating red hematite, the ratios range from 1.69:1 to 1.056:1; and in magnetite they range from 3.89:1 to 1.041:1.

Beneficiated iron ore shipped from mines in the United States, 1916 and 1917.

State.	Variety.	1916		1917	
		Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Alabama	Red hematite, brown ore	996,344	$1,969,706	1,159,624	$3,324,715
Georgia	Brown ore	104,583	196,771	88,156	223,171
Minnesota	Red hematite	4,576,249	10,801,034	4,576,626	13,471,608
New Jersey	Magnetite	528,084	1,877,056	471,253	2,325,723
New York	Red hematite, brown ore, magnetite	1,042,823	4,104,398	958,979	5,446,881
North Carolina	Brown ore, magnetite	(a)	(a)	38,163	216,929
Pennsylvania	Brown ore, magnetite	208,351	776,830	215,380	1,031,296
Tennessee	Red hematite, brown ore, magnetite	331,499	533,266	334,254	739,505
Virginia	Brown ore, magnetite	155,436	307,653	134,215	350,203
Other States [b]	Red hematite, brown ore, magnetite	161,642	470,650	189,914	603,005
		8,105,011	21,037,364	8,166,564	27,733,036

[a] Included in "Other States."

[b] 1916: Connecticut, Iowa, Maryland, Massachusetts, Michigan, Missouri, and North Carolina. 1917: Connecticut, Iowa, Maryland, Massachusetts, Michigan, Missouri, and New Mexico.

IRON AND STEEL.

The records of the production and sales of iron and steel for 1917 in comparison with former years are shown in the following pages, the data being derived from several authoritative sources, such as the American Iron and Steel Institute, Metal Statistics, the Iron Age, the Iron Trade Review, the Bureau of Foreign and Domestic Commerce, and especially from the producers who report directly to the United States Geological Survey.

PIG IRON.

PRODUCTION, SHIPMENTS, AND VALUE, BY STATES.

The bureau of statistics of the American Iron and Steel Institute reports the production in 1917 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces as well as some that were electrically produced, as amounting to 38,621,216 gross tons, compared with 39,434,797 tons produced in 1916, a decrease of 813,581 tons, or about 2 per cent.

Pig iron, including some ferroalloys, manufactured in the United States in 1913 and 1917, in gross tons.[a]

	1916	1917		1916	1917
Pennsylvania	16,506,284	15,539,728	Virginia	399,885	520,311
Ohio	8,602,895	8,518,603	Missouri	437,633	453,742
Illinois	3,922,512	3,456,915	Iowa[b]		
Alabama	2,762,885	2,953,706	Colorado		
Indiana	2,221,708	2,657,503	Washington		
Michigan			California		
New York	2,352,535	2,417,527	Maryland	501,452	422,212
New Jersey			Tennessee	355,374	369,951
Wisconsin	811,325	738,541	Connecticut	5,719	10,527
Minnesota			Massachusetts		
West Virginia	554,590	561,951		39,434,797	38,621,216
Georgia					
Kentucky					

[a] Bureau of statistics of the American Iron and Steel Institute.
[b] Ferrosilicon produced in electric furnace for first time in 1916.

According to reports to the United States Geological Survey by the manufacturers, the shipments of pig iron, exclusive of ferroalloys, in 1917 amounted to 38,612,546 gross tons, valued f. o. b. at the furnaces at $1,053,785,975, as compared with 39,126,324 tons, valued at $663,478,118, in 1916, a decrease in quantity of 513,778 tons, or 1.3 per cent, and an increase in gross value of $390,307,857, or nearly 59 per cent. These values represent the approximate amounts received for the iron f. o. b. at the furnaces, and eliminate freight costs, selling commissions, and other items which are included in some of the market prices of pig iron as published in the trade journals.

The pig iron shipped includes the metal produced from foreign as well as from domestic ore. The quantity and value of pig iron derived from ore imported from Africa, Canada, Cuba, Spain, and Sweden, although it constitutes a very small percentage of the total production, is considerable, as it is calculated that the shipments derived from foreign ore in 1917 amounted to 505,216 gross tons, valued at $14,381,196, as compared with 764,850 tons, valued at

$15,996,756, in 1916. In the manufacture in 1917 of 486,561 gross tons of pig iron, 912,630 gross tons of foreign iron ore were reported to have been used, thus indicating an average pig-iron yield of 53.31 per cent, as compared with the quantity of imported ore. Domestic ore including 5,484,267 tons of cinder, scale, scrap, etc., and amounting to 74,592,448 gross tons, was reported in 1917 as used in the manufacture of 37,437,929 tons of pig iron, thus indicating a yield of 50.19 per cent in pig iron from the domestic materials. The total production in 1917 of pig iron, exclusive of ferroalloys, reported to the Survey was 37,924,490 gross tons.

Pig iron shipped from blast furnaces in the United States in 1916 and 1917.

State.	1916		1917		Change in 1917.		Percentage of change, 1917.	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity.	Value.
Alabama	$2,672,498	38,994,660	2,971,626	$64,309,714	+ 299,128	+$25,315,054	+ 11	+ 65
Illinois	3,857,391	67,764,309	3,458,126	91,094,541	− 399,265	+ 23,330,232	− 10	+ 35
Kentucky	144,444	2,595,600	192,204	5,532,367	+ 47,760	+ 2,936,767	+ 33	+113
Michigan	505,646	8,851,361	611,446	18,300,501	+ 105,800	+ 9,449,140	+ 21	+107
New Jersey	(a)	(a)	187,753	6,618,536	(b)	(b)	(b)	(b)
New York	2,289,608	40,537,240	2,276,367	52,318,661	− 13,241	+ 11,781,421	− .6	+ 29
Ohio	8,689,030	136,855,228	8,469,052	231,165,093	− 219,978	+ 94,309,865	− 3	+ 69
Pennsylvania	16,351,131	293,437,782	15,423,262	460,677,474	− 927,869	+167,239,692	− 6	+ 57
Tennessee	329,342	4,981,538	346,638	9,102,441	+ 17,296	+ 4,120,903	+ 5	+ 83
Virginia	444,491	7,140,002	562,299	15,703,295	+ 117,808	+ 8,563,293	+ 26	+120
Wisconsin	423,973	7,534,327	402,732	11,032,274	− 21,241	+ 3,497,947	− 5	+ 46
Other states [c]	3,418,770	54,786,071	3,711,041	87,931,078	+[b]480,024	+[b]39,763,543	+[b]14	+[b]73
	39,126,324	663,478,118	38,612,546	1,053,785,975	− 513,778	+390,307,857	− 1.3	+ 59

[a] Included with "Other States."

[b] Increase in New Jersey included in "Other States."

[c] 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia. 1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia.

AVERAGE PRICES.

The average price per gross ton of all kinds of pig iron, by States, from 1912 to 1917, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the approximate prices f. o. b. at the blast furnaces and do not include the prices of ferroalloys.

The general average prices for 1916 and 1917 appear low for such active years in the iron industry. At the close of 1916 market prices of pig iron were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year (see fig. 8), so that the average increase in price was only 28 per cent as compared with 1915. In 1917, however, the course of prices was very different, for at the beginning and end of the year prices were more nearly the same with the high levels at the middle of the year. The curve (fig. 8) of market prices of basic iron at Valley furnaces reflects this unusual condition. The general average price for all grades of pig iron at the furnaces, exclusive of ferroalloys, for the year 1917 was $27.29, as compared with $16.96 in 1916, an increase of $10.33 a ton, or nearly 61 per cent. The States in which the average selling price of pig iron was more than $30 a ton were Connecticut, Georgia, Massachusetts, Missouri, New Jersey, and Washington.

Average price per gross ton of pig iron in the United States, 1912 to 1917.

State.	1912	1913	1914	1915	1916	1917
Alabama	$10.75	$12.08	$10.52	$10.24	$14.59	$21.64
Illinois	15.26	15.83	13.59	13.93	17.57	26.34
Kentucky	15.74	16.09	12.24	13.44	17.97	28.78
Michigan	14.30	14.69	13.78	13.63	17.51	29.93
New Jersey	(a)	(a)	(a)	(a)	(a)	35.25
New York	14.22	15.35	14.26	14.02	17.70	22.98
Ohio	13.07	15.02	13.46	12.96	15.75	27.30
Pennsylvania	14.60	15.36	13.78	13.69	17.95	29.87
Tennessee	12.29	13.22	12.05	12.09	15.13	26.26
Virginia	13.27	13.96	12.53	12.83	16.06	27.93
Wisconsin	14.33	15.13	13.35	13.20	17.77	27.39
Other States [b]	14.07	15.50	13.56	12.96	16.03	24.25
Average for United States	13.93	15.08	13.42	13.21	16.96	27.29

[a] Included in "Other States."

[b] 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia.

In the following summary of the annual average price per gross ton of pig iron in the United States for the years 1889 to 1917, the prices prior to 1907 include the cost of transportation of some pig iron from blast furnaces to markets. Prior to 1910 the values of blast-furnace ferroalloys are included. Since 1910 the prices represent, as closely as can be ascertained, the average price paid for pig iron at the blast furnaces. The extreme range in prices is from $9.76 in 1894 to $27.29 in 1917. The lowest prices were in the years 1894 to 1898, and the highest (except for 1917) were in the years 1902 to 1907.

Average price per gross ton of pig iron in the United States, 1889–1917.

1889	$15.78	1899	$18.00	1909	$16.25
1890	16.43	1900	18.85	1910	15.45
1891	15.50	1901	15.25	1911	14.07
1892	14.32	1902	20.92	1912	13.93
1893	11.90	1903	19.12	1913	15.08
1894	9.76	1904	14.13	1914	13.42
1895	11.14	1905	16.63	1915	13.21
1896	10.47	1906	19.98	1916	16.96
1897	9.85	1907	20.56	1917	27.29
1898	9.90	1908	15.96		

MARKET PRICES.

The average monthly prices of the principal grades of pig iron either at the blast furnaces or at the nearest market for 1916 and 1917, according to published market quotations, are of interest in comparison with the general average prices per ton of pig iron in the United States ($16.96 and $27.29) reported to the Survey by blast-furnace operators. The accompanying diagram (fig. 8) graphically shows the price curve of basic pig iron at the blast furnaces in the Mahoning and Shenango valleys, Ohio and Pennsylvania, 1912 to 1917, inclusive. Beginning at $30 a ton in 1917 the price rose almost steadily from February to July, when it reached $52.50 per

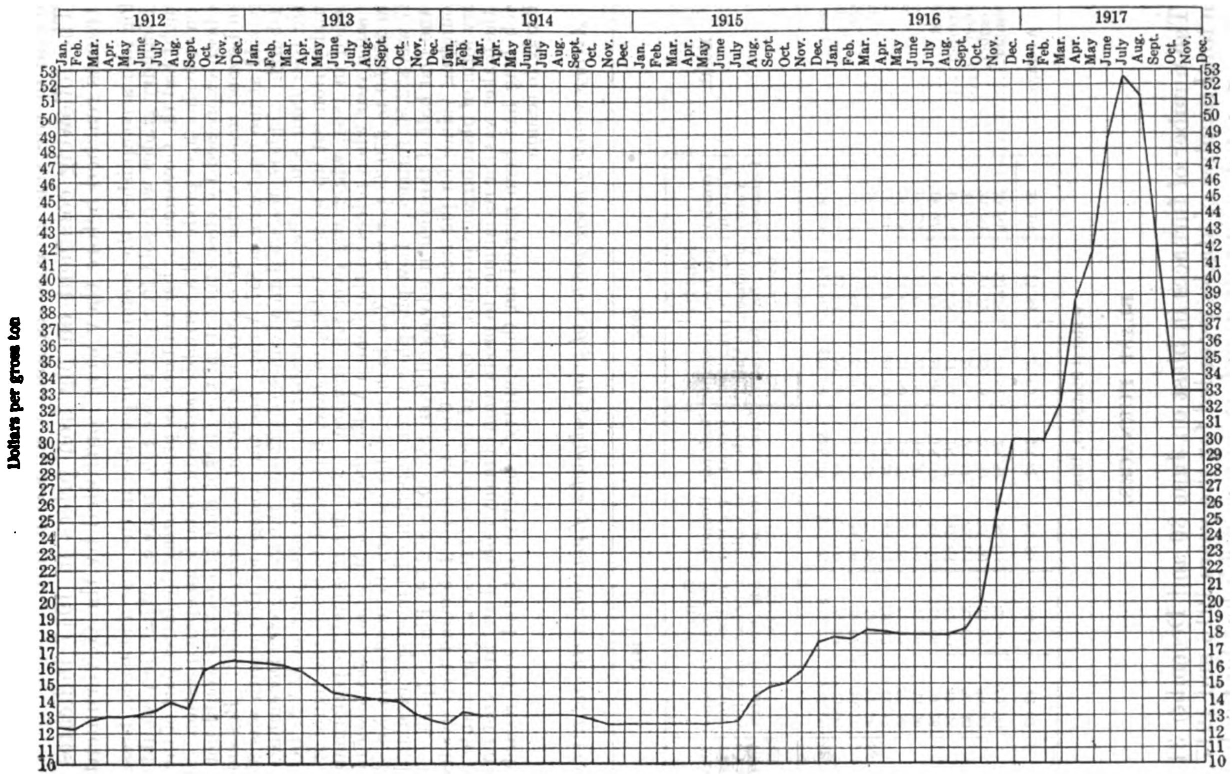


FIGURE 8.—Curve showing prices of basic pig iron at blast furnaces in Mahoning and Shenango valleys, Ohio and western Pennsylvania, 1912 to 1917, by months. Statistics from the Iron Age, Jan. 3, 1918, p. 68.

ton, according to the Iron Age (and $53.52, according to Metal Statistics). These figures are among the top prices paid for this grade of pig iron since the Civil War. The effect of Government price regulation brought it down precipitately so that from October until the end of the year it was stationary at $33 a ton.

The following comment on pig iron prices in 1917 indicates the extremes reached before they were controlled by the Government.[1]

> Pig iron accomplished the seemingly impossible in the year and basic, Bessemer, and foundry grades were sold freely at above $50, furnace. What they would have brought had the Government bar not been on prices during the latter part of the year when coke shortages produced a veritable famine of metal is an open question. Belief has been expressed by close students of the market that $75 to $100 would not have been beyond reason under the economic situation that then obtained. Bessemer in July sold at the top figure of $57, Valley, and the average for that month was $57.95, Pittsburgh. This represented an advance of $22 over the average for December, 1916. Basic rose from $30, Valley, in December of the previous year to $52.25 in July. Foundry iron got up to $55, Valley, in July, but failed to reach the figure it commanded in 1864, which was over $73, furnace. Nor did it equal its performance of the same year when prices in the Lehigh Valley between May and December ranged from $59.50 to $70.25 per ton. The high price for eastern Pennsylvania No. 2X in 1917 was $52.50, furnace. Low phosphorus iron experienced a most spectacular flight. In the first half of the year it advanced from $53.50 to $92.50, Philadelphia. These astounding values for pig iron symbolize the unexampled demand that existed for every form of blast furnace product. One of the effects of these very profitable prices for the maker was the reclaiming to production of many isolated and high-cost furnaces which long had been carried on the country's inactive list and were regarded as unlikely to resume.

Average monthly prices per ton of principal grades of pig iron, 1916 and 1917.[a]

Month.	1916				1917			
	Foundry pig iron at Valley furnaces.	Foundry pig iron at Birmingham, Ala., furnaces.	Bessemer pig iron at Valley furnaces.	Basic pig iron at Valley furnaces.	Foundry pig iron at Valley furnaces.	Foundry pig iron at Birmingham, Ala., furnaces.	Bessemer pig iron at Valley furnaces.	Basic pig iron at Valley furnaces.
January	$18.50	$14.92	$21.00	$18.00	$30.00	$24.27	$35.00	$30.00
February	18.50	14.64	20.50	17.88	30.00	24.13	35.00	30.00
March	18.50	15.00	20.67	18.48	34.96	29.67	36.70	31.93
April	18.50	15.00	21.00	18.48	39.16	33.76	41.36	38.52
May	18.44	15.00	21.00	18.21	42.65	36.62	44.12	41.46
June	18.39	14.63	21.00	18.25	49.19	40.92	53.50	49.23
July	18.25	14.00	21.00	18.00	53.00	45.36	55.56	53.52
August	18.27	14.00	21.00	18.00	53.00	45.00	54.26	51.70
September	18.58	14.38	21.33	18.27	47.68	42.60	47.58	43.80
October	20.56	15.35	23.81	20.17	33.00	33.00	36.30	33.00
November	25.60	19.72	29.40	24.80	33.00	33.00	36.30	33.00
December	29.84	23.38	34.84	29.84	33.00	33.00	36.30	33.00
Average	20.16	15.84	23.05	19.87	39.89	35.11	42.67	39.10

[a] Metal Statistics, 1918.

BLAST FURNACES.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1916 and 1917, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

---

[1] Iron Trade Rev., Jan. 3, 1918, pp. 16–17.

Blast furnaces in the United States, 1916 and 1917.

State.	Furnaces in blast June 30, 1916.	Dec. 31, 1916.			Furnaces in blast June 30, 1917.	Dec. 31, 1917.		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	132	127	30	157	136	122	41	163
Ohio	67	65	12	77	72	64	15	79
Illinois	23	24	0	24	22	18	7	25
Alabama	31	29	18	47	34	34	13	47
New York	20	18	9	27	21	21	4	25
Virginia	9	9	13	22	12	15	4	19
Tennessee	12	11	7	18	12	10	6	16
Colorado	4	3	3	6	4	3	3	6
Missouri	1	2	0	2	2	2	0	2
Oregon	0	0	1	1	0	0	1	1
Washington	......	......	......	......	0	0	1	1
California	0	0	0	0	0	0	1	1
Maryland	4	4	1	5	4	2	3	5
New Jersey	1	1	4	5	4	5	0	5
Wisconsin	6	5	3	8	6	5	3	8
Minnesota	3	3	0	3	3	3	0	3
Indiana	10	10	0	10	12	13	1	14
Michigan	12	12	2	14	12	12	2	14
West Virginia	4	4	0	4	4	3	1	4
Kentucky	4	4	2	6	4	4	3	7
Georgia	0	0	4	4	0	1	3	4
Texas	0	0	2	2	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Connecticut	0	1	2	3	2	2	1	3
Massachusetts	1	1	1	2	1	1	1	2
	344	333	115	448	367	340	117	457

MONTHLY PRODUCTION OF PIG IRON.

The accompanying diagram (fig. 9) illustrates the course of the manufacture of pig iron by months during the last six years. The rising production of 1912 and early 1913, the decline from the middle of 1913 to the close of 1914 broken by feeble rallies in March and August, 1914, the rapid rise in production from month to month throughout 1915 broken only slightly in November, the high level maintained continuously above 3,000,000 tons throughout 1916, culminating in the record production in October of 3,508,849 gross tons, and the generally high level maintained in 1917 broken only by decreases to below 3,000,000 tons in February and December, are graphically indicated.

PRODUCTION OF PIG IRON, BY GRADES.

The statistics of production of the principal grades of pig iron have been published by the American Iron and Steel Institute for 1913 to 1917, as follows:

Pig iron manufactured in the United States, 1913–1917, by grades, in gross tons.

Grade.	1913	1914	1915	1916	1917
Bessmer and low phosphorus	11,590,113	7,859,127	10,523,306	14,422,457	13,714,732
Basic (mineral fuel)	[a] 12,536,693	[a] 9,670,687	[a] 13,093,214	17,684,087	17,671,662
Forge pig iron	324,407	361,651	316,214	348,344	345,707
Foundry and ferrosilicon	5,220,343	4,533,254	4,864,348	5,553,644	5,328,258
Malleable	993,736	671,771	829,921	921,486	1,015,579
Spiegeleisen	110,338	79,935	97,885	194,002	192,985
Ferromanganese	119,495	106,083	129,072	221,532	260,125
White, mottled, direct castings, etc	71,027	49,736	62,253	89,245	92,168
	30,966,152	23,332,244	29,916,213	39,434,797	38,621,216

[a] Includes a small quantity of basic iron made with charcoal.

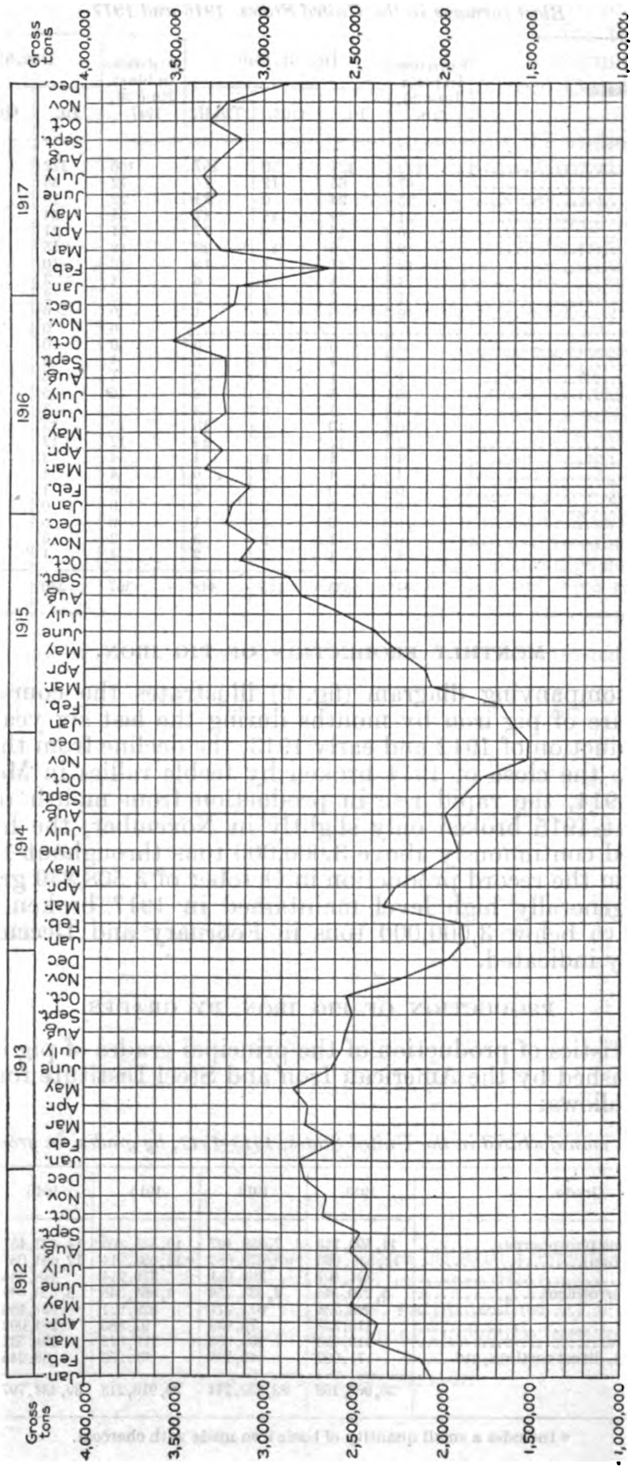


FIGURE 9.—Curve showing production of coke and anthracite pig iron in the United States, 1912–1917, by months. Statistics from the Iron Age, Jan. 10, 1918.

PRODUCTION OF PIG IRON ACCORDING TO FUEL USED.

In the following table are given the statistics of the American Iron and Steel Institute showing the production of pig iron, according to the fuel used, from 1913 to 1917. The charcoal figures include small quantities of pig iron made with charcoal and electricity. The totals for each of the five years also include small quantities of ferroalloys made with electricity and with coke and electricity.

Pig iron manufactured in the United States, 1913–1917, by fuel used, in gross tons.

Fuel used.	1913	1914	1915	1916	1917
Bituminous, chiefly coke	30,326,130	22,976,856	29,535,308	38,844,598	37,863,643
Anthracite and coke	277,595	89,569	84,753	217,788	381,048
Anthracite alone	22,446	1,895	....	....	....
Charcoal	339,981	263,924	296,152	372,411	376,525
	30,966,152	23,332,244	29,916,213	39,434,797	38,621,216

TOTAL PRODUCTION OF PIG IRON.

The next table shows the production in the United States of pig iron, including the commoner ferroalloys, as far as has been recorded. The statistics for 1912 to 1917 are those of the American Iron and Steel Institute; those for the years from 1854 to 1911 were collected by the American Iron and Steel Association; those for 1810, 1840, and 1850 are census figures; those for the other years are largely estimates by early statisticians.

Pig iron manufactured in the United States, 1810–1917, in gross tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1810	53,908	1866	1,205,663	1893	7,124,502
1820	20,000	1867	1,305,023	1894	6,657,388
1828	130,000	1868	1,431,250	1895	9,446,308
1829	142,000	1869	1,711,287	1896	8,623,127
1830	165,000	1870	1,665,179	1897	9,652,680
1831	191,000	1871	1,706,793	1808	11,773,934
1832	200,000	1872	2,548,713	1899	13,620,703
1840	286,903	1873	2,560,963	1900	13,789,242
1842	215,000	1874	2,401,262	1901	15,878,354
1846	765,000	1875	2,023,733	1902	17,821,307
1847	800,000	1876	1,868,961	1903	18,009,252
1848	800,000	1877	2,066,594	1904	16,497,033
1849	650,000	1878	2,301,215	1905	22,992,380
1850	563,755	1879	2,741,853	1906	25,307,191
1852	500,000	1880	3,835,191	1907	25,781,361
1854	657,337	1881	4,144,254	1908	15,936,018
1855	700,150	1882	4,623,323	1909	25,795,471
1856	788,515	1883	4,595,510	1910	27,303,567
1857	712,640	1884	4,097,868	1911	23,649,547
1858	629,548	1885	4,044,526	1912	29,726,937
1859	750,560	1886	5,683,329	1913	30,966,152
1860	821,223	1887	6,417,148	1914	23,332,244
1861	653,164	1888	6,489,738	1915	29,916,213
1862	703,270	1889	7,603,642	1916	39,434,797
1863	846,075	1890	9,202,703	1917	38,621,216
1864	1,014,282	1891	8,279,870		
1865	831,770	1892	9,157,000		627,960,624

FOREIGN TRADE IN PIG IRON.

IMPORTS.

The quantity of pig iron and ferroalloys, the principal of which were ferromanganese and ferrosilicon, imported into the United States in 1917 was 76,786 gross tons, compared with 135,349 tons imported in 1916, a decrease of 58,563 tons, or 43 per cent. Separate statistics of imports of ferroalloys given on page 599 indicate that the imports of pig iron alone (by difference) were 21,023 gross tons in 1917 compared with 37,533 tons in 1916, a decrease of 16,510 tons, or nearly 44 per cent. The United Kingdom furnished the largest quantity of these products in both years; Canada and China followed in order of importance in 1917.

The statistics of imports of iron are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce, and the following table gives the imports from the various countries from 1913 to 1917:

Pig iron, including kentledge, ferromanganese, ferrosilicon, and spiegeleisen, imported into the United States, 1913–1917, in gross tons.

Country.	1913	1914	1915	1916	1917
North America:					
Canada	4,609	25,968	21,166	33,716	21,143
Newfoundland and Labrador		200			
West Indies	72				83
South America		250			
Europe:					
Austria-Hungary	340	899			
Belgium	256	500			
France	179	40	20		
Germany	8,358	10,609	600	341	
Italy		550			20
Netherlands	460	2,539			
Norway	117	225			
Sweden	2,002	2,329	1,392	792	
Switzerland	1,680				
United Kingdom: England	131,340	90,627	59,105	89,764	51,384
United Kingdom: Scotland	1,581	1,012	792		250
Asia:					
British India	2,439	1,310	2,382	1,313	
China	3,017	200	3,430	8,861	3,503
China, leased territory (British)		1,285			
Hongkong		200			
Japan		70	250	562	85
Oceania		90			
Other countries			699		318
	156,450	138,903	89,836	135,349	76,786

EXPORTS.

The quantity of pig iron exported from the United States in 1917 was 656,220 gross tons, compared with 607,236 tons in 1916, an increase of 48,984 tons, or 8 per cent. The increase in value, from $15,381,431 in 1916 to $24,037,051 in 1917, represented more than 56 per cent. The largest quantity was shipped in 1916 and 1917 to Italy, and considerable quantities were shipped also to Canada, England, and France, and Japan became a larger purchaser in 1917, but exports to Denmark and the Netherlands decreased notably. Several European countries were added to the list in 1916, and the exports to Switzerland, Denmark, Netherlands, Spain, Norway, and Sweden at this time were due to war conditions in Europe.

The following table has been compiled from records of the Bureau of Foreign and Domestic Commerce:

Pig iron exported from the United States to foreign countries, 1913–1917, in gross tons.

Country.	1913	1914	1915	1916	1917
North America:					
Canada	193,396	57,852	60,197	101,277	153,745
Costa Rica	310	18	50	68	26
Mexico	85	454	684	676	920
Panama	3,921	1,056	2,316	1,968	1,816
West Indies:					
Cuba	646	593	844	5,338	4,243
South America:					
Argentina	792	1,042	912	380	2,580
Brazil	1,305	575	304	1,176	1,483
Chile	690	1,875	2,716	6,500	8,888
Peru	172	200	286	682	578
Europe:					
Austria-Hungary	4,601	1,150	....	....	....
Belgium	4,715	1,219	....	....	....
Denmark	48	....	....	17,380	1,836
France	752	397	9,414	71,226	65,618
Germany	1,723	749	....	....	....
Greece	....	....	....	50	....
Italy	21,551	14,288	81,792	234,213	184,763
Netherlands	1,516	1,467	1,993	22,464	2,124
Norway	....	....	....	11,267	12,986
Russia in Europe	....	....	....	926	6,017
Spain	....	....	....	8,464	5,891
Sweden	....	....	....	20,707	17,799
Switzerland	....	....	....	3,671	1,404
United Kingdom—					
England	20,972	18,013	57,368	88,315	138,196
Scotland	396	148	....	2,249	7,874
Ireland	26	....	....	357	1,610
Asia:					
Japan	2,293	2,938	1,811	5,033	30,809
Oceania:					
Australia	14,354	10,099	2,008	433	257
New Zealand	85	....	....	260	760
All other countries	299	290	1,814	2,156	3,997
	277,648	114,423	224,509	607,236	656,220
Value	$4,026,306	$1,638,102	$3,667,167	$15,381,431	$24,037,061

PRODUCTION OF PIG IRON IN PRINCIPAL COUNTRIES.

The following table is taken from Metal Statistics, 1918. The grand totals are regarded as representing the world's production of pig iron:

Pig iron manufactured in principal countries in 1850, 1890, 1900, 1910, 1913, 1915, and 1916, in gross tons.[a]

Country.	1850	1890	1900	1910	1913	1915[b]	1916[c]
United States	563,755	9,202,703	13,789,242	27,303,567	30,966,152	29,916,213	39,434,797
Germany	350,000	4,584,882	8,381,373	14,559,509	19,004,022	11,603,874	13,000,000
Great Britain	2,300,000	7,904,214	8,959,691	10,217,022	10,481,917	8,793,659	9,047,983
France	405,653	1,931,188	2,669,966	3,974,478	5,227,378	4,000,000	5,000,000
Russia	227,555	912,561	2,889,789	2,992,058	4,474,757	3,638,000	4,300,000
Austria-Hungary	250,000	910,685	1,472,695	2,153,788	2,335,170	1,929,000	2,000,000
Belgium	144,452	775,385	1,001,872	1,822,821	2,318,767	500,000	1,000,000
Canada	....	19,439	86,090	740,210	1,015,118	825,420	1,069,541
Sweden	150,000	483,155	518,263	594,385	728,103	755,000	750,000
Spain	....	176,598	289,315	367,423	418,061	421,000	440,000
Italy	....	14,094	23,569	347,657	420,011	389,000	454,923
Other countries	10,000	80,000	100,000	400,000	500,000	500,000	500,000
	4,401,415	26,994,904	40,181,865	65,472,918	77,889,856	63,271,166	77,000,000

---

[a] Metal Statistics, 1918, p. 49.
[b] Partly estimated.
[c] Largely estimated. Production in Belgium wholly, and in France largely, by Germans.

FERROALLOYS.[1]

The activity in the domestic ferroalloy industry that developed in 1916 continued unabated during 1917. The general situation has been reviewed by Anderson[2] and Johnson[3] and the ferromanganese and spiegeleisen situation by Cone[4] and Stone.[5] Thus far the Survey has obtained more or less incomplete statistics of production and value for the alloys of iron with manganese, silicon, phosphorus, tungsten, molybdenum, chromium, vanadium, titanium, uranium, and cerium, but there are small quantities of alloys with many other metals, and elements, among which might be mentioned aluminum, boron, cobalt, nickel, tantalum, zinc, and zirconium, upon which no data have been obtained.

SHIPMENTS AND VALUE.

The quantity of ferroalloys of all classes reported as shipped or used and which the Survey is at liberty to publish amounted to only about 1.64 per cent of the total marketed production of pig iron during 1917, but the value per ton is so much greater as to have an important influence on the apparent average value of the pig iron, if included with it, and would make it $28.98 a ton, instead of $27.29. The quantity reported falls short of the actual production of the United States, as the output of certain electrically produced ferroalloys is not available for publication by the Geological Survey.

There is a sufficient number of producers of the commoner ferroalloys, such as ferromanganese, spiegeleisen, and ferrosilicon, to enable the Survey to publish the reported production of these three types of alloys separately; but the production of the rarer alloys, among which are ferrochrome, ferromolybdenum, ferrovanadium, and ferrouranium, must be grouped together, and as there are less than three reporting producers of ferrophosphorus the value of this alloy is grouped with that of ferrosilicon, although permission to show quantity was given for 1916.

The shipments of ferroalloys of all classes in 1917, as reported to the United States Geological Survey, were 634,021 gross tons, valued at $83,731,724, as compared with 589,738 gross tons, valued at $50,281,692, in 1916, an increase in quantity of 44,283 tons, or 7.5 per cent, and in value of $33,450,032, or 66.5 per cent, in 1917. Of the shipments in 1917, it is calculated that 267,667 gross tons, valued at $56,186,626, were made from imported ores derived from Bolivia, Brazil, China, Costa Rica, Cuba, India, Japan, Mexico, Nova Scotia, Panama, Peru, Porto Rico, and Quebec. The ferrovanadium, ferromolybdenum, ferromanganese, spiegeleisen, ferrotungsten, and ferrocarbontitanium were made in part or wholly from imported ore.

The sales of ferromanganese and spiegeleisen of domestic manufacture in 1917 amounted to 449,466 gross tons, valued at $63,687,007, compared with 406,940 gross tons, valued at $36,281,695, sold in 1916. The figures for ferromanganese and spiegeleisen, which may be shown separately for the last two years, are as follows: For 1917 ferromanganese 260,225 gross tons, valued at $53,930,771, or an average of $207.25 a ton; spiegeleisen, 189,241 gross tons, valued at $9,756,236, or an average of $51.55 a ton; for 1916, ferromanganese, 224,103 gross tons, valued at $30,123,493, or an average of $134.42 a ton; spiegeleisen, 182,837 gross tons, valued at $6,158,202, or $33.68 a ton. The continued increases in value are noteworthy. The sales of ferrosilicon and ferrophosphorus in 1917 amounted to 175,079 gross tons, valued at $8,562,182 an average value of $48.90 a ton, compared with 179,274 tons, valued at $5,273,088, or $29.41 a ton, in 1916. The sales of alloys of iron with the rarer metals—chromium, cerium, molybdenum, tungsten, titanium, uranium, and vanadium—as reported to the Survey, amounted in 1917 to 9,476 gross tons, valued at $11,482,535, compared with 3,524 gross tons, valued at $8,726,909, in 1916, an increase in quantity of 5,952 tons and in value of $2,755,626. These alloys were therefore valued at an average price of nearly $1,212 a ton in 1917, compared with $2,476 a ton in 1916. Ferrotungsten shipments in 1917 were 1,258 gross tons, valued at $4,225,070, or an average of $3,359 a ton.[1]

---

[1] Notes on ores used in manganese ferroalloys are given also in the chapter on the production of manganese and manganiferous ores in Mineral Resources for 1917, and notes on ores for certain other ferroalloys in the chapters on chrome ore and ores of other rare metals.

[2] Anderson, R. J., Metallurgical ferroalloys in 1917: Eng. and Min. Jour., Jan. 26, 1918, pp. 191–193.

[3] Johnson, J. E., jr., Phases of iron and steel metallurgy in 1917: Iron Age, Jan. 3, 1918, pp. 77–82, and 128.

[4] Cone, E. F., Spiegeleisen in place of ferromanganese: Iron Age, Jan. 3, 1918, pp. 40–41, and 129.

[5] Stone, G. C., Ferromanganese and spiegeleisen: Idem, Jan. 12, 1918, pp. 75–76.

The following table gives an incomplete outline of the sales of ferroalloys in the United States in 1915, 1916, and 1917:

Ferroalloys of domestic manufacture shipped in 1915, 1916, and 1917.

Variety of alloy.	1915		1916		1917	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Ferromanganese	144,260	$9,253,443	224,103	$30,123,493	260,225	$53,930,771
Spiegeleisen	114,556	2,403,550	182,837	6,158,202	189,241	9,756,236
Ferrosilicon	128,263	2,595,265	166,308	5,273,088	175,079	8,562,182
Ferrophosphorus			12,966			
Ferrotungsten (50 per cent or more tungsten)	(a)	(a)	(a)	(a)	1,258	4,225,070
Other varieties[b]	1,565	3,198,127	3,524	8,726,909	8,218	7,257,465
	388,644	17,450,385	589,738	50,281,692	634,021	83,731,724

[a] Included with "Other varieties."

[b] 1915: Ferromolybdenum, ferrotungsten, and ferrovanadium; 1916: Ferrochrome, ferromolybdenum, ferrotungsten, and ferrovanadium; 1917: Ferrocerium, ferrochrome, ferromolybdenum, ferrocarbontitanium, ferrouranium, and ferrovanadium.

In 1917 ferromanganese was reported to have been made at 23 localities in the United States, spiegeleisen at 18 places, ferrosilicon at 17 places, ferrophosphorus at 1 place, ferrocerium at 1 place, ferrochrome at 4 places, ferromolybdenum at 3 places, ferrocarbontitanium at 1 place, ferrotungsten at 8 places, ferrouranium at 1 place, and ferrovanadium at 4 places.

The following table shows the number of localities by States at which the principal ferroalloys were manufactured in 1916 and 1917, but these operations do not include all those at which ferroalloys are manufactured electrically. In all there were reported 81 localities at which ferroalloys were made in 1917, compared with 46 localities in 1916.

---

[1] Quotations of market prices of ferroalloys and of the ores of the rare metals entering into the same may be found in current issues of Metallurgical and Chemical Engineering.

Number of places, by States, at which ferroalloys were manufactured in 1916 and 1917.

State and alloy.	1916	1917	State and alloy.	1916	1917
Alabama:			New York:		
Ferromanganese	2	3	Ferromanganese	0	1
Spiegeleisen	2	3	Ferrosilicon	1	5
California:			Ferrocarbontitanium	0	1
Ferromanganese	1	1	Ferrotungsten	0	1
Ferrosilicon	0	1	Ohio:		
Ferrochrome	1	1	Ferrosilicon	4	4
Ferromolybdenum	0	1	Oregon:		
Ferrotungsten	0	1	Ferromanganese	0	1
Colorado:			Pennsylvania:		
Spiegeleisen	1	1	Ferromanganese	8	9
Ferrosilicon	0	1	Spiegeleisen	7	9
Ferrochrome	0	1	Ferrosilicon	1	1
Ferromolybdenum	0	1	Ferrocerium	0	1
Ferrotungsten	0	2	Ferrochrome	0	1
Illinois:			Ferromolybdenum	1	1
Ferromanganese	2	2	Ferrotungsten	3	3
Spiegeleisen	1	2	Ferrouranium	0	1
Ferrosilicon	1	0	Ferrovanadium	3	4
Iowa:			Tennessee:		
Ferrosilicon	1	1	Ferrosilicon	0	2
Kentucky:			Ferrophosphorus	2	1
Ferrosilicon	1	1	Virginia:		
Maryland:			Ferromanganese	0	2
Ferromanganese	1	1	Spiegeleisen	0	3
Ferrosilicon	1	1	Washington:		
Ferrotungsten	0	1	Ferromanganese	0	2
Spiegeleisen	1	0	Ferrochrome	0	1
New Jersey:					
Ferromanganese	0	1		46	81

The following records of average contract prices of 80 per cent ferromanganese at eastern seaboard and 20 per cent spiegeleisen by months for the last three years are of interest:

Prices per ton of ferromanganese and spiegeleisen, 1915, 1916, and 1917.

Month.	Ferromanganese.			Spiegeleisen.		
	1915[a]	1916[a]	1917[b]	1915[a]	1916[a]	1917[b]
January	$68.00	$110.00	$175.00	$26.00	$32.50	$57.50
February	100.00	140.00	192.50	25.50	42.50	66.25
March	100.00	175.00	212.50	26.00	55.00	77.50
April	100.00	175.00	250.00	26.00	60.00	76.75
May	100.00	175.00	375.00	26.00	60.00	78.00
June	105.00	175.00	400.00	26.00	55.00	83.00
July	103.00	175.00	400.00	26.00	47.50	85.00
August	105.00	170.00	387.50	26.00	47.50	81.25
September	110.00	164.00	380.00	29.00	45.00	80.50
October	105.00	160.00	300.00	30.00	40.00	73.50
November	100.00	155.00	247.50	30.00	45.00	63.25
December	100.00	162.50	250.00	30.00	50.00	60.30

[a] Iron Trade Review, Jan. 4, 1917, p. 25.
[b] Idem, Jan. 3, 1918, p. 25.

IMPORTS.

According to the reports of the Bureau of Foreign and Domestic Commerce, the imports for consumption of all classes of ferroalloys into the United States in 1917 were 55,763 gross tons, valued at $6,703,330, compared with 97,816 tons, valued at $9,792,747, in

1916. The imports of ferromanganese were 41,969 gross tons, valued at $5,710,988, or $136.08 a ton, as compared with 90,928 gross tons, valued at $9,240,528, or $101.62 a ton, in 1916. The imports of spiegeleisen in 1917 amounted to 3,968 gross tons, valued at $291,594, or $73.48 a ton, as contrasted with no imports of this alloy in 1916. The imports of the alloys of the rarer metals are not all reported separately. For instance, the imports of ferrochrome are combined with those of chromium, those of ferromolybdenum are combined with those of the metal molybdenum, and those of ferrotungsten are included with those of tungsten. For the sake of comparison, however, such statistics as are available are presented in the following two tables:

Ferroalloys imported for consumption in the United States in 1915, 1916, and 1917.

Variety of alloy.	1915		1916		1917	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Chrome or chromium and ferrochrome	32	$1,662	10	$1,998	....	....
Ferrophosphorus	12	617	....	....	85	$5,458
Ferrosilicon	5,128	311,219	6,740	384,384	9,740	691,684
Molybdenum and ferromolybdenum	....	203	....	....	....	....
Titanium and ferrotitanium	....	....	100	8,126	....	....
Tungsten and ferrotungsten	7	9,588	38	157,711	1	3,606
Ferromanganese	55,263	3,333,699	90,928	9,240,528	41,969	5,710,988
Spiegeleisen	200	5,110	....	....	3,968	291,594
	60,642	3,662,098	97,816	9,792,747	55,763	6,703,330

Ferromanganese and ferrosilicon imported into the United States in 1915, 1916, and 1917.

[General imports.]

Country.	Alloy.	1915		1916		1917	
		Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
British India	Ferromanganese	....	....	[a] 1,313	$190,649	....	....
Canada	Ferrosilicon	4,887	$274,059	6,691	379,132	9,729	$689,902
England	Ferromanganese	....	....	[a] 41,832	4,626,509	45,059	6,054,188
	Ferrosilicon	319	33,165	49	5,251	....	....
Scotland	Ferromanganese	....	....	....	....	250	38,932
France	Ferrosilicon	20	2,906	....	....	....	....
Japan	Ferromanganese	....	....	....	....	72	14,259
	Ferrosilicon	....	....	....	....	11	1,782

[a] Included in "All other pig iron" prior to July, 1916.

PRODUCTION OF STEEL, BY STATES AND KINDS.

The following tables showing the production of steel were compiled by the bureau of statistics of the American Iron and Steel Institute. No data whatever are available on the value of the steel output.

Bessemer steel ingots and castings manufactured in the United States, 1913–1917, in gross tons.

State.	1913	1914	1915	1916	1917
Ohio	4,024,662	2,862,700	3,929,665	4,711,784	4,256,337
Pennsylvania	2,954,818	2,014,526	2,507,243	3,444,163	3,537,094
Illinois	1,475,274	871,110	1,270,502	1,958,259	1,683,960
Other States	1,090,952	472,510	579,803	944,833	1,002,569
	9,545,706	6,220,846	8,287,213	11,059,039	10,479,960

Open-hearth steel ingots and castings manufactured in the United States, 1913–1917, in gross tons.

State.	1913	1914	1915	1916	1917
New England States	195,419	137,962	191,582	278,768	332,597
New York and New Jersey	996,312	719,227	1,266,017	1,872,258	2,110,846
Pennsylvania	12,522,227	9,854,038	13,245,393	16,030,251	16,284,102
Ohio	2,726,219	2,592,778	3,521,404	5,057,751	6,074,857
Indiana	2,180,106	1,628,840	2,504,427	3,243,961	3,722,931
Illinois	1,264,854	896,610	1,169,657	1,812,169	1,966,296
Other States	1,714,794	1,345,229	1,780,622	3,120,269	3,657,264
	21,599,931	17,174,684	23,679,102	31,415,427	34,148,893

According to these tables there was a decrease of 5 per cent in the production of Bessemer steel in 1917 compared with that of 1916, and an increase of 9 per cent in open-hearth steel. In the total production of steel in 1917 there was an increase of 5 per cent compared with 1916. Of the total output in 1917, 76 per cent was represented by open-hearth steel, 23 per cent by Bessemer steel, and less than 1 per cent by all other classes of steel.

PRODUCTION OF ELECTRIC STEEL.

The production of steel by the electric process in 1917 amounted to 304,543 gross tons, as compared with 168,918 tons in 1916, an increase of 135,625 tons, or more than 80 per cent. The following table gives the production of electric steel ingots and castings since 1909. In 1908 there were 55 tons of electric steel produced, but this quantity was included with open-hearth steel for that year.

Steel electrically manufactured in the United States, 1909 to 1917, in gross tons.

Year.	Ingots.	Castings.	Total.
1909	13,456	306	13,762
1910	50,821	1,320	52,141
1911	27,227	1,878	29,105
1912	14,147	4,162	18,309
1913	20,973	9,207	30,180
1914	15,458	8,551	24,009
1915	46,348	23,064	69,412
1916	126,048	42,870	168,918
1917	239,632	64,911	304,543

In the total production of electric steel in 1915 are included 27,944 tons of steel ingots and castings which were treated with ferrovanadium, ferrotitanium, ferrochrome, and other alloys, of which 27,848 tons were ingots and 96 tons were castings. In 1916 the production of similarly treated steel amounted to about 71,129 tons—70,203 tons of ingots and 926 tons of castings—and in 1917 it amounted to 130,578 tons—129,282 tons of ingots and 1,296 tons of castings.

On December 31, 1917, the number of completed plants which were equipped for the manufacture of steel by the electric process was 89, as compared with 57 plants at the close of 1916, a gain of 32 plants. The statistics of electric steel have been furnished by the American Iron and Steel Institute.

TOTAL DOMESTIC PRODUCTION OF STEEL.

Steel produced in the United States, 1810–1917, in gross tons.

Year.	Bessemer.	Open-hearth.	Crucible.	Other Steel.	Total.
1810	....	....	917		917
1860	....	....	11,838		11,838
1863	....	....	8,075		8,075
1864	....	....	9,258		9,258
1865	....	....	13,627		13,627
1866	....	....	16,940		16,940
1867	2,679	....	16,964		19,643
1868	7,589	....	19,197		26,786
1869	10,714	893	19,643		31,250
1870	37,500	1,339	29,911		68,750
1871	40,179	1,785	31,250		73,214
1872	107,239	2.679	26,125	6,911	142,954
1873	152,308	3,125	31,059	12,244	198,796
1874	171,309	6,250	32,436	5,672	215,727
1875	335,283	8,080	35,180	11,256	389,799
1876	469,639	19,187	35,163	9,202	533,191
1877	500,524	22,349	36,098	10,647	569,618
1878	653,773	32,255	38,309	7,640	731,977
1879	829,439	50,259	50,696	4,879	935,273
1880	1,074,202	100,851	64,664	7,558	1,247,335
1881	1,374,247	131.202	80,145	2,720	1,588,314
1882	1,514,687	143,341	75,973	2,691	1,736,692
1883	1,477,345	119,356	71,835	4,999	1,673,535
1884	1,375,531	117,515	53,270	4,563	1,550,879
1885	1,519,430	133,376	57,599	1,515	1,711,920
1886	2,269,190	218,973	71,973	2,367	2,562,503
1887	2,986,033	322,069	75,375	5,594	3,339,071
1888	2,511,161	314,318	70,279	3,682	2,899,440
1889	2,930,204	374,543	75,865	5,120	3,385,732
1890	3,688.871	513,232	71,175	3,793	4,277,071
1891	3,247,417	579,753	72,586	4,484	3,904,240
1892	4,168,435	669,889	84,700	4,548	4,927,581
1893	3,215,686	737,890	63,613	2,806	4,019,995
1894	3,571,313	784,936	51,702	4,081	4,412,032
1895	4,909,128	1,137,182	67,666	858	6,114,834
1896	3,919,906	1,298,700	60,689	2,394	5,281,689
1897	5,475,315	1,608,671	69,959	3,012	7,156,957
1898	6,609,017	2,230,292	89.747	3,801	8,932,857
1899	7,586,354	2,947,316	101,213	4,974	10,639,857
1900	6,684,770	3,398,135	100,562	4,862	10,188,329
1901	8,713.302	4,656,309	98,513	5,471	13,473,595
1902	9,138,303	5,687,729	112,772	8,386	14,947,250
1903	8.592,829	5,829,911	102,434	9,804	14,534,978
1904	7,859,140	5,908.166	83,391	9.190	13,859,887
1905	10,941,375	8,971,376	102,233	8,963	20.023,947
1906	12,275,830	10,980,413	127,513	14,380	23,398,136
1907	11.667,549	11,549,736	131,234	14,075	23,362,594
1908	6.116,755	7,836,729	63,631	6,132	14,023,247
1909	9,330,783	14,493,936	107,355	22,947	23,955,021
1910	9,412,772	16,504,509	122,303	55,335	26,094,919
1911	7,947,854	15,598,650	97,653	31,949	23,676,106
1912	10,327,901	20.780.723	121,517	21,162	31,251,308
1913	9,545,706	21,599,931	121,226	34,011	31,300,874
1914	6,220,846	17,174,681	89,869	27,631	23.513,030
1915	8,287,213	23,679,102	113,782	70,939	32,151.086
1916	11,059,039	31,415,427	129,692	169,522	42,773,680
1917	10,479,960	34,148,893	126,716	305,038	45,060,607

FOREIGN TRADE IN STEEL.

The extraordinary development of the export trade in steel in the United States since the beginning of the war in Europe is indicated in the table of exports which shows, by classes, the exports of manufactured iron and steel from this country in 1915, 1916, and 1917. For comparison the imports are tabulated also. The figures were compiled from records of the Bureau of Foreign and Domestic Commerce.

In 1915, 1916, and 1917 the quantity of iron and steel exports (so far as recorded) increased 149 per cent, 66 per cent and 5 per cent, respectively, but the total values increased 133 per cent, 136 per cent, and 57 per cent, respectively.

Iron and steel imported into the United States, 1915. 1916, and 1917.

Article.	1915		1916		1917	
	Quantity (gross tons.)	Value.	Quantity (gross tons.)	Value.	Quantity (gross tons.)	Value.
Scrap iron and steel	79,982	$761,719	116,039	$1,140,704	180,034	$2,437,423
Bar iron	8,474	417,491	7,701	647,393	2,240	193,831
Ingots, blooms, slabs, etc., not elsewhere specified	4,412	187,623	11,487	430,323	35,861	1,635,323
Ingots, blooms, and slabs, billets and bars of steel, and steel in forms, not elsewhere specified	10,586	1,753,978	17,792	2,809,319	8,337	2,313,613
Hoop or band iron or steel for baling	....	28	....	....	....	....
Rails for railway	78.525	2,088,532	26,299	740,109	9,263	307,139
Sheets and plates	1,420	218,954	1,938	345,622	1,747	526,788
Tin and terne plates	2,350	196,328	1,129	214,574	124	31,453
Wire rods	5,317	331,724	4,625	509,559	1,060	221,184
	191,066	5,956,377	187,010	6,837,603	238,666	7.666,754
Wire and articles made from wire	....	640,521	....	652,889	....	348,876
All other manufactures: free	....	200,763	....	105,896	....	82,993
dutiable	....	2.324,447	....	3,503,219	....	4,072,935
	....	3,165,731	....	4,261,004	....	4,504,804
Grand total	....	9,122,108	....	11,098,607	....	12,171,556

Iron and steel exported from the United States, 1915, 1916, and 1917.

Article.	1915		1916		1917	
	Quantity (gross tons.)	Value.	Quantity (gross tons.)	Value.	Quantity (gross tons.)	Value.
Scrap and old, fit only for manufacture	79,361	$1,111,254	212,765	$3,689,675	145,574	$3,362,562
Bar iron	39,740	1,471,466	74,069	3,913,849	56,332	5,046,727
Bars or rods (of steel), wire rods	165,015	4,713,109	158,284	8,109,111	181,941	15,356,275
All other	425,678	16,412,440	774,455	47,670,406	626,465	59,708,761
Billets, ingots, and blooms, not elsewhere specified	560,704	14,176,528	1,504,562	90,095,601	2,017,113	161,391,007
Bolts and nuts	23,536	1,896,842	29,227	3,132,897	32,261	5,259,622
Hoop and bands	29,249	1,433,879	43,208	3,251,882	58,769	7,330,301
Horseshoes	15,863	2,741,724	7,806	1,007,198	8,403	1,594,952
Cut nails	4,236	190,667	4,752	312,195	4,525	434,736
Railroad spikes	13,256	591,752	23,852	1,489,091	21,188	2,009,808
Wire nails	91,584	4,371,072	150,173	10,794,418	114,912	12,088,147
All other (including tacks)	9,251	1,085,416	12,353	1,637,051	19,351	3,867,606
Cast-iron pipes and fittings	47,022	2,128,025	70,223	3,988,293	77,528	7,483,216
Wrought-iron pipes and fittings	129,966	8,081,416	158,350	13,195,696	127,191	16,659,553
Radiators and cast-iron house-heating boilers	2,291	183,523	2,424	232,845	5,201	672,331
Rails for railways, of steel	391,379	12,095,170	540,828	20,417,582	512,669	24,023,090
Galvanized iron and steel plates	75,905	5,381,303	85,304	8,350,005	86,487	13,207,827
Iron sheets and plates, all other	25,543	1,221,699	46,499	3,136,262	62,238	7,540,780
Steel plates	223,806	8,037,551	276,034	16,499,757	525,660	65,888,695
Steel sheets	94,349	3,726,933	107,721	6,546,814	157,354	18,654,553
Structural iron and steel	232,139	8,960,411	300,594	17,541,862	294,150	24,437,289
Tin and terne plates	154,641	11,501,995	227,391	21,352,177	232,797	41,888,418
Barbed wire	248,611	13,933,234	418,882	31,230,905	193,471	19,775,784
All other wire	224,972	11,900,373	264,142	20,994,035	201,472	22,541,224
	3,308,097	137,347,782	5,493,898	338,589,607	5,763,052	540,218,263
Axes		588,443		722,520		1,023,184
Hammers and hatchets		509,824		366,161		568,892
Railway-track material, switches, frogs, fishplates, splices, bars, etc		4,857,047		6,540,187		8,194,270
Saws		1,294,447		2,923,055		5,113,514
Shovels and spades		352,727		666,407		509,559
All other tools		8,676,483		12,716,778		14,095,939
		16,278,971		23,935,108		29,506,358
Grand total		153,626,753		362,524,715		569,724,621

GOLD AND SILVER.

(GENERAL REPORT.)

By H. D. McCaskey and J. P. Dunlop.

ACKNOWLEDGMENTS.

To those engaged in the mining and metallurgic industries, to merchants, bankers, and transportation officials of the United States and Alaska, to the Bureau of the Mint, the Post Office Department, and the Bureau of Foreign and Domestic Commerce of the Department of Commerce, and to other officials, public and private, who have cooperated with the United States Geological Survey by furnishing information on the production of gold and silver, acknowledgment is gratefully made. To the authors of the Survey mines reports on the production of gold, silver, copper, lead, and zinc in the Eastern, Central, and Western States, and in Alaska, Messrs. B. S. Butler, C. N. Gerry, V. C. Heikes, Charles W. Henderson, James M. Hill, G. C. Martin, and Charles G. Yale, the writers are especially indebted.

PRODUCTION.

DOMESTIC PRODUCTION.

Approximate distribution, by producing States and Territories, of the production of gold and silver in the United States for 1917.[a]

State or Territory.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
Alabama	106	$2,200	....	....
Alaska	709,729	14,671,400	1,207,164	$994,100
Arizona	250,613	5,180,600	6,962,257	5,733,400
California	1,012,461	20,929,400	2,107,107	1,735,200
Colorado	772,766	15,974,500	7,291,495	6,004,500
Georgia	314	6,500	....	....
Idaho	36.511	754,800	11,402,542	9,390,080
Illinois	....	....	7,116	5,900
Maryland	....	....	538	400
Michigan	....	....	684,225	563,400
Missouri	15	300	63,344	52,200
Montana	177,690	3,673,200	14,555,034	11.986,100
Nevada	335,361	6,932.500	11,217,654	9,237,700
New Mexico	52,505	1,085,400	1,535,807	1,264,700
North Carolina	524	10.800	590	500
Oregon	81,624	1,687,300	172,152	141,800
Philippine Islands	69,953	1,446,100	12,715	10,500
Porto Rico	5	100	....	....
South Carolina	82	1.700	....	....
South Dakota	356,662	7,372,900	190,382	156,800
Tennessee	267	5.500	106,975	88,100
Texas	5	100	587,945	484,200
Utah	170,383	3,522,100	13,360,905	11,002,700
Vermont	5	100	403	300
Virginia	63	1,300	4,500	3,700
Washington	23,617	488,200	266,112	219,100
Wyoming	179	3,700	3,400	2,800
	4,051,440	83,750,700	71,740,362	59,078,100

---

[a] Gold value $20.67+ per fine ounce. Average commercial (dealers') buying price of silver 0.999 fine in 1917, 82.4 cents per fine ounce.

The figures in this table result from cooperation of the United States Bureau of the Mint and the United States Geological Survey and are agreed upon after conference and adjustment between the two bureaus. They are, therefore, final for both.

The totals are based on bullion deposits in the United States mints and assay offices and on returns to the Bureau of the Mint from the smelting and refining companies. The distribution is adjusted by information collected by the United States Geological Survey directly from the producing mines and tabulated for the mines reports later discussed. The data giving the total production, and in part the distribution, are obtained from records of (1) the unrefined domestic gold and silver deposited in United States mints and assay offices, (2) the domestic gold and silver in fine bars reported by private refineries, and (3) the unrefined domestic gold and silver contained in ores and matte exported for reduction. The last item is of small relative importance.

Increase or decrease in production of gold and silver in the United States in 1917.

State or Territory.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
Alabama	− 252	− $5,200		
Alaska	− 70,308	−1,453,400	− 59,153	+ $161,100
Arizona	+ 52,624	+1,087,800	+ 282,005	+ 1,338,800
California	− 50,841	−1,051,000	+ 170,197	+ 461,000
Colorado	−155,309	−3,210,500	− 260,266	+ 1,036,600
Georgia	− 673	− 13,900		
Idaho	− 14,684	− 303,500	− 167,857	+ 1,778,500
Illinois			+ 1,384	+ 2,100
Maryland			+ 385	+ 300
Michigan			− 74,843	+ 64,100
Missouri	+ 15	+ 300	− 65,516	− 32,600
Montana	− 31,696	− 655,200	+ 508,980	+ 2,746,000
New Hampshire			− 935	− 600
Nevada	−103,144	−2,132,200	−2,464,413	+ 237,100
New Mexico	− 12,801	− 264,600	− 194,110	+ 126,700
North Carolina	− 589	− 12,200	− 1,148	− 600
Oklahoma			− 606	− 400
Oregon	− 10,361	− 214,200	− 49,735	− 4,200
Philippine Islands	− 3,296	− 68,100	− 4,928	− 1,100
Porto Rico	− 24	− 500		
South Carolina	+ 67	+ 1,400		
South Dakota	− 4,782	− 98,800	− 19,718	+ 18,600
Tennessee	− 9	− 200	+ 13,138	+ 26,400
Texas	− 19	− 400	− 76,374	+ 47,200
Utah	− 16,296	− 336,900	− 184,897	+ 2,091,700
Vermont	− 9	− 200	− 1,561	− 1,000
Virginia	+ 39	+ 800	+ 3,992	+ 3,400
Washington	− 4,470	− 92,400	− 28,404	+ 25,400
Wyoming	− 798	− 16,500	− 7	+ 600
Increase or decrease	−427,616	−8,839,600	−2,674,440	+10,125,100

In addition to the production of gold and silver by domestic smelters and refiners from domestic sources in 1917, amounting to 4,051,440 fine ounces of gold and 71,740,362 fine ounces of silver, these plants produced 769,171 fine ounces of gold and 50,106,811 fine ounces of silver from foreign ores. These figures represent a decrease of 31,634 ounces of gold and an increase of 3,855,794 ounces of silver compared with the corresponding figures for 1916. The foreign ores producing this bullion were mainly from Mexico and Canada.

The value of the new gold used in the arts and industries in the United States in 1917 was $34,803,445, and the quantity of silver used for such purposes in 1917 was 15,998,807 fine ounces.

PRICES OF SILVER.

The average official monthly prices of fine bar silver in New York in 1917 were as follows:

Price of silver per fine ounce in 1917, by months.[1]

January	$0.7598	August	$0.86125
February	.7771	September	1.05026
March	.74023	October	.87692
April	.7400	November	.86672
May	.74875	December	.88015
June	.77447		
July	.80845	Yearly average	.8235

The average annual price of silver per fine ounce from 1865 to 1917, inclusive, has been as follows:

Price of silver per fine ounce, 1865–1917.[2]

1865	$1.337	1883	$1.11	1901	$0.60
1866	1.339	1884	1.11	1902	.53
1867	1.33	1885	1.07	1903	.54
1868	1.326	1886	.99	1904	.58
1869	1.325	1887	.98	1905	.61
1870	1.328	1888	.94	1906	.68
1871	1.325	1889	.94	1907	.66
1872	1.322	1890	1.05	1908	.53
1873	1.297	1891	.99	1909	.52
1874	1.278	1892	.87	1910	.54
1875	1.24	1893	.78	1911	.53
1876	1.16	1894	.63	1912	.615
1877	1.20	1895	.65	1913	.604
1878	1.15	1896	.68	1914	.553
1879	1.12	1897	.60	1915	.519
1880	1.15	1898	.59	1916	.658
1881	1.13	1899	.60	1917	.824
1882	1.14	1900	.62		

PRODUCTION OF GOLD AND SILVER SINCE 1792.

According to tables published by the Director of the Mint the total production of gold and silver in the United States is as follows:

Gold and silver produced in the United States, 1792–1917.

[The estimate for 1792–1872 is by R. W. Raymond, commissioner, and for the period since 1872 by the Director of the Mint.]

Period.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
1792–1847	1,187,170	$24,587,000	309,500	$404,500
1848–1872	58,279,778	1,204,750,000	118,568,200	157,749,900
1873–1917	129,810,577	2,683,420,900	2,260,659,739	1,736,859,300
	189,277,525	3,912,707,900	2,379,537,439	1,895,013,700

---

[1] This represents average official quotations for sale by the Mint and is above dealers' prices for silver 0.999 fine.

[2] Based on London price of bar silver 1.000 fine and taken at average price and par of exchange.

These figures show a total production of gold for the United States, from the earliest mining to the end of 1917, of 189,277,525 ounces, valued at nearly $3,913,000,000, and an output of silver of nearly 2,380,000,000 ounces, valued at more than $1,895,000,000. Although the production of gold was less than one-twelfth the output of silver in quantity, its value was more than twice that of the silver.

The average commercial value per fine ounce of silver for the 125 years contributing to the total domestic production was a little less than $0.80. Fluctuations in value of silver per fine ounce are shown in the curve on figure 10. It is of interest to note that the average value for the total output of silver was reached in 1893. For the years shown (1871 to 1917, inclusive) the average annual value was above $0.80 before 1893, and has been below that figure every year since until 1917, when the average value was $0.8235, or 2.35 cents more than the average value 1871–1916.

Gold and silver produced in the United States, 1880–1917.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
1880	1,741,500	$36,000,000	30,318,700	$34,717,000
1881	1,678,612	34,700,000	33,257,800	37,657,500
1882	1,572,187	32,500,000	36,196,900	41,105,900
1883	1,451,250	30,000,000	35,732,800	39,618,400
1884	1,489,950	30,800,000	37,743,800	41,921,300
1885	1,538,373	31,801,000	39,909,400	42,503,500
1886	1,686,788	34,869,000	39,694,000	39,482,400
1887	1,603,049	33,136,000	41,721,600	40,887,200
1888	1,604,478	33,167,500	45,792,700	43,045,100
1889	1,594,775	32,967,000	50,094,500	46,838,400
1890	1,588,877	32,845,000	54,516,300	57,242,100
1891	1,604,840	33,175,000	58,330,000	57,630,000
1892	1,597,098	33,015,000	63,500,000	55,662,500
1893	1,739,323	35,955,000	60,000,000	46,800,000
1894	1,910,813	39,500,000	49,500,000	31,422,100
1895	2,254,760	46,610,000	55,727,000	36,445,500
1896	2,568,132	53,088,000	58,834,800	39,654,600
1897	2,774,935	57,363,000	53,860,000	32,316,000
1898	3,118,398	64,463,000	54,438,000	32,118,400
1899	3,437,210	71,053,400	54,764,500	32,858,700
1900	3,829,897	79,171,000	57,647,000	35,741,100
1901	3,805,500	78,666,700	55,214,000	33,128,400
1902	3,870,000	80,000,000	55,500,000	29,415,000
1903	3,560,000	73,591,700	54,300,000	29,322,000
1904	3,892,480	80,464,700	57,682,800	33,456,000
1905	4,265,742	88,180,700	56,101,600	34,222,000
1906	4,565,333	94,373,800	56,517,900	38,256,400
1907	4,374,827	90,435,700	56,514,700	37,299,700
1908	4,574,340	94,560,000	52,440,800	28,050,600
1909	4,821,701	99,673,400	54,721,500	28,455,200
1910	4,657,018	96,269,100	57,137,900	30,854,500
1911	4,687,053	96,890,000	60,399,400	32,615,700
1912	4,520,717	93,451,500	63,766,800	39,197,500
1913	4,299,783	88,884,400	66,801,500	40,348,100
1914	4,572,976	94,531,800	72,455,100	40,067,700
1915	4,887,602	101,035,700	74,961,075	37,397,300
1916	4,479,056	92,590,300	74,414,802	48,953,000
1917	4,051,440	83,750,700	71,740,362	59,078,100
	116,270,813	2,403,529,100	2,052,250,039	1,485,784,900

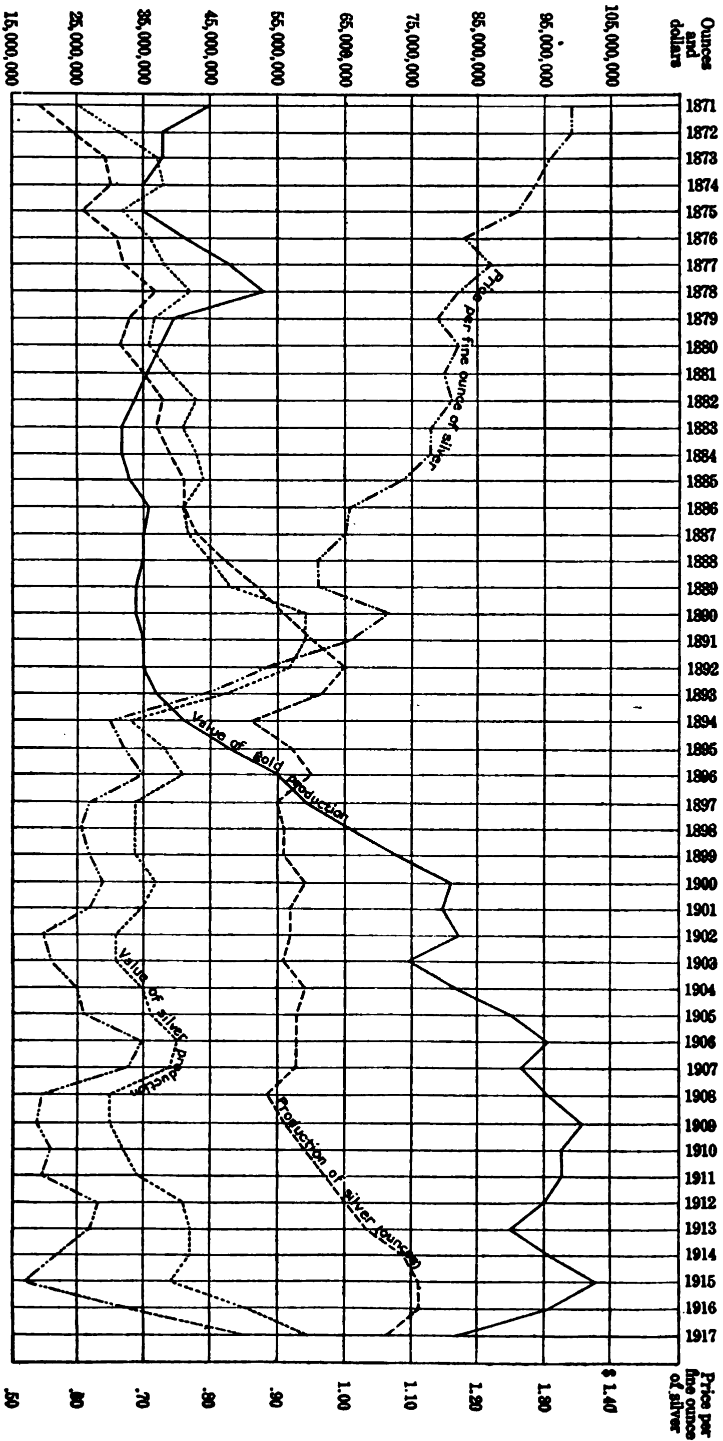


FIGURE 10.—Curves showing production and value of gold and silver and price per fine ounce of silver in the United States, 1871-1917.

IMPORTS AND EXPORTS.

Value of gold and silver imported and exported, 1917.

[Figures furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce.]

Metal.	Imports.	Exports.	Excess of—	
			Imports.	Exports.
GOLD.				
Contained in domestic ore and base bullion		$251,963		$251,963
Contained in foreign ore and base bullion	$15,508,581		$15,508,581	
Domestic bullion refined		90,212,645		90,212,645
Foreign bullion refined	401,687,827	31,470	401,656,357	
United States coin	62,312,573	274,036,206		211,723,633
Foreign coin	72,945,398	7,351,600	65,593,798	
	552,454,374	371,883,884	482,758,731	302,188,241
Excess			180,570,490	
SILVER.				
Contained in domestic ore and base bullion		167,326		167,326
Contained in foreign ore and base bullion	37,668,562		37,668,562	
Domestic bullion refined		76,555,369		76,555,369
Foreign bullion refined	9,497,753	3,214,819	6,282,934	
United States coin	1,162,009	1,003,379	158,630	
Foreign coin	5,012,153	3,189,983	1,822,170	
	53,340,477	84,130,876	45,932,296	76,722,695
Excess				30,790,399

DOMESTIC SUPPLY.

The remarkable gain in domestic supply of gold indicated by the great excess of $530,200,000 in imports over exports for 1916, or $76,000,000 more than the world's total output of new gold for the year, was due to the fact that this country has been a creditor nation since the last great movements of its gold abroad. This movement was much less conspicuous in 1917, though the excess of imports of gold in ore bullion and coin amounted to more than $180,000,000, due largely to the imports of foreign refined bullion. The continuation of large exports of silver to the Far East, and especially to the entente nations in Europe, was due largely to demand for exchange and for the coinage of silver money to pay troops in the field. The quantity of refined domestic silver bullion exported was more than double the silver contained in imported foreign ore and base bullion.

The domestic supply of new gold comes chiefly from dry or siliceous gold ores, treated in gold mills by amalgamation or cyanidation, or both, and from placer gravels largely by dredging. As shown on page 645 these ores and placer gravels supplied 25.8 per cent of the yield of gold in 1917. Examples of gold-milling ores are those of the Homestake mines of South Dakota, the Goldfield mines in Nevada, the Grass Valley and Mother Lode mines of California, the Alaska mines of the Juneau district, and the Cripple Creek and upper San Miguel County mines in Colorado. The great gold-dredging fields of California, especially of the Marysville district, are examples of the placer gravels worked on a large scale. A considerable output of gold is also now recovered from the refining of copper bullion from copper ores, especially of the West Mountain or Bingham district, Utah, the Robinson or Ely district, Nev., and the Summit Valley or Butte district, Mont. In 1917 the copper ores of the United States produced more than 8.7 per cent of the total gold, against 9 per cent in 1916. The natural tendency is for the proportionate output from gold ores to decrease, with declining yield from some of the principal gold camps, and for that from copper ores to increase, with a general net falling off of total yield of gold owing to the preponderant output from gold and gold-silver ores.

The principal domestic supply of new silver comes from dry or siliceous silver and silver-gold ores, from copper ores, from lead ores, and from lead-zinc ores—in the proportion of 30.4, 28.8, 27, and 12.2 per cent, respectively, in 1917, against 31.2, 31.1, 24.4, and 10.9 per cent, respectively, in 1916. The dry or siliceous silver-gold ores have come chiefly from four large mines of the Tonopah district, Nev., and declining output from this camp more than offsets gains from such ores elsewhere. The bulk of the silver ores of this class are milled and cyanided at or near the mines, although a small quantity of richer ores is shipped to copper and lead smelters. The largest single producer of silver in 1917 from domestic mines was the Anaconda Copper Co., of Montana, producing from copper ores; the second largest was the Hercules Mining Co., of Idaho, producing from lead ores; and the third largest was the Tonopah Belmont Mining Co., of Nevada, producing from siliceous ores. Of the 25 mines or groups of mines producing silver on the largest scale, 8 were silver-gold and silver mines, 6 were copper mines, 10 were lead mines, and 1 was a zinc-lead mine. With large recent increase in output of argentiferous copper, lead, and zinc-lead ores, the domestic silver output has been fairly well maintained against decline from silver-gold and (the rare) silver ores. The silver obtained as a by-product from copper, lead, and zinc ores is derived from refining the copper and lead bullion produced in smelting those and other ores.

WORLD'S PRODUCTION OF GOLD.

Value of gold produced in the world, 1860–1917.

[The annual production from 1860 to 1872 is obtained from statistics for 5-year periods compiled by Dr. Adolph Soetbeer. Since 1872 the estimates are those of the Bureau of the Mint.]

Calendar year.	Value.	Calendar year.	Value.	Calendar year.	Value.	Calendar year.	Value.
1860	$134,083,000	1875	$97,500,000	1890	$118,848,700	1905	$380,288,700
1861	122,989,000	1876	103,700,000	1891	130,650,000	1906	402,503,000
1862	122,989,000	1877	113,947,200	1892	146,651,500	1907	412,966,600
1863	122,989,000	1878	119,092,800	1893	157,494,800	1908	442,476,900
1864	122,989,000	1879	108,778,800	1894	181,175,600	1909	454,059,100
1865	122,989,000	1880	106,436,800	1895	198,763,600	1910	455,239,100
1866	129,614,000	1881	103,023,100	1896	202,251,600	1911	461,939,700
1867	129,614,000	1882	101,996,600	1897	236,083,700	1912	466,136,100
1868	129,614,000	1883	95,392,000	1989	286,879,700	1913	460,497,204
1869	129,614,000	1884	101,729,600	1899	306,724,100	1914	439,029,702
1870	129,614,000	1885	108,435,600	1900	254,576,300	1915	468,724,918
1871	115,577,000	1886	106,163,900	1901	260,992,900	1916	454,176,500
1872	115,577,000	1887	105,774,900	1902	296,737,600	1917	423,590,200
1873	96,200,000	1888	110,196,900	1903	327,702,700		
1874	90,750,000	1889	123,489,200	1904	347,377,200		12,595,397,124

The peak of the world's production of gold was reached in 1915 (see Pl. IV), when most of the great gold fields were contributing maximum outputs. In 1916 declines in the United States, Russia (and Siberia), and Australasia more than offset an increase in Africa.

In 1917 the estimated total production of gold in the world decreased more than $30,000,000. The production of the United States decreased nearly $9,000,000, Canada $4,000,000, Africa $8,000,000, Australasia $4,500,000, and Russia $4,500,000.

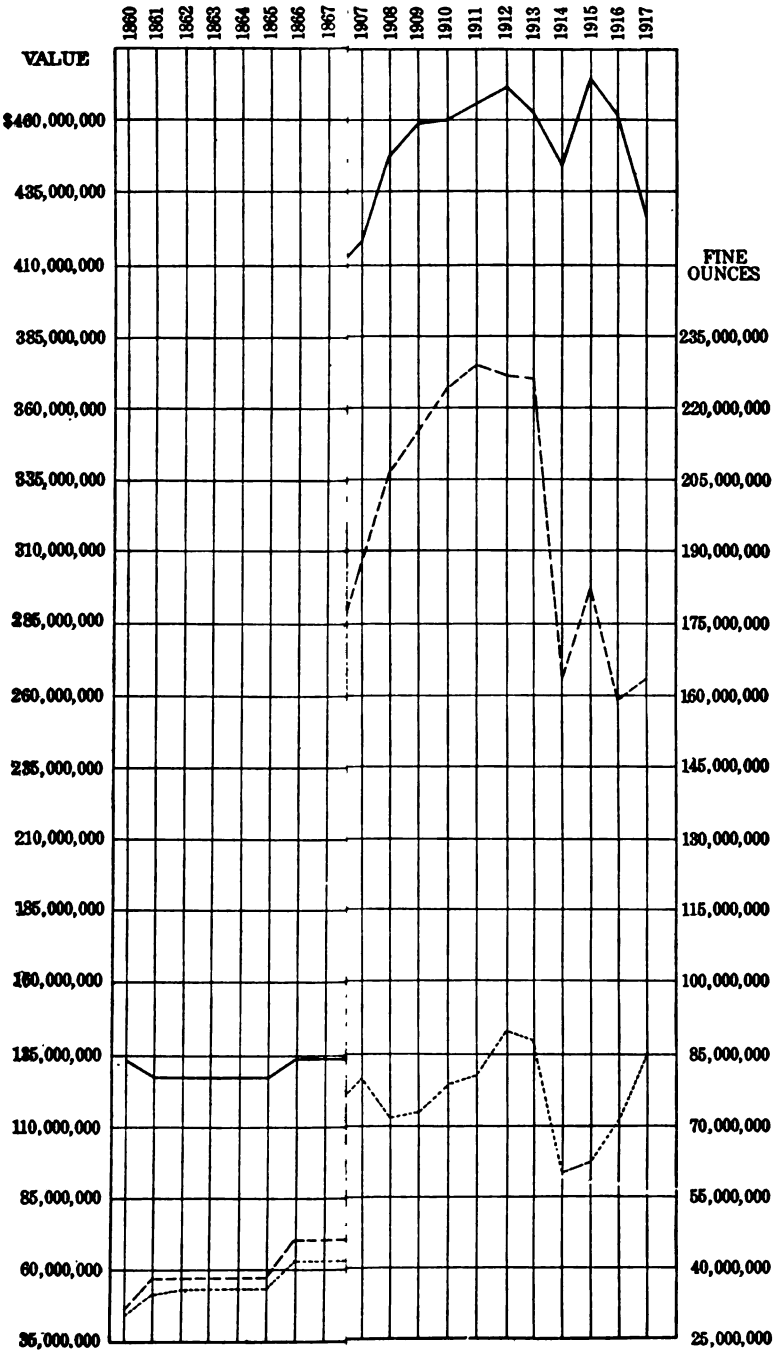
The high-water mark of silver output was reached in 1911, when Mexico, Canada, and Australasia were all producing at or near the maximum. Increased output from the United States has not offset large falling off in the above-named countries, especially Mexico, in the last six years,

A valuable paper on "Gold and silver deposits in North and South America" was read by Waldemar Lindgren at the Second Pan American Scientific Congress and has been republished in the Transactions of the American Institute of Mining Engineers, volume 55, pages 883–909, 1917.

In the following table is shown the output of gold, by countries, as given by the Bureau of the Mint:

World's production of gold, 1904–1917.

Country.	1904	1905	1906	1907	1908	1909	1910
North America:							
United States	$80,464,700	$88,180,700	$94,373,800	$90,435,700	$94,560,000	$99,673,400	$96,269.100
Canada	16,462,500	14,610,400	12,023,900	8,382,800	9,482,100	9,382,200	10,205,800
Mexico	12,605,300	16,107,100	18,534,700	18,681,100	22,371,200	23,842,900	24,910,600
Africa	85,913,900	113,254,700	135,358,000	151,984,100	166,520,500	170,988,600	175,189,900
Australasia	87,767,300	85,926,500	82,391,400	75,677,700	73,327,300	71,007,900	65,470,600
Europe:							
Russia and Finland	24,803,200	22,292,200	19,496,500	26,684,300	28,052,200	32,381,300	35,579,600
Austria-Hungary	2,117,300	2,457,400	2,615,400	2,484,900	2,469,300	1,942,000	2,172,600
Germany	64,700	66,700	80,400	66,600	64,800	69,200	62,900
Norway	....	....	....	....	....	....	1,400
Sweden	40,200	36,700	13,300	18,700	14,500	10,100	2,000
Italy	44,000	44,000	41,200	39,600	46,500	24,200	29,600
Spain and Portugal	....	....	....	....	....	2,900	2,800
Turkey	29,000	6,000	6,000	4,560	2,200	500	500
France	....	....	502,400	835,400	1,147,400	1,400,600	1,707,100
Great Britain	359,800	112,700	29,200	29,200	16,000	21,500	39,600
Serbia	....	....	59,800	59,800	59,800	150,300	....
South America:							
Argentina	9,200	5,500	5,500	103,000	161,300	189,900	173,100
Bolivia	21,900	18,800	754,600	1,267,400	346,300	492,400	463,600
Chile	636,900	948,500					
Colombia	1,947 400	2 584,000	2,190,800	3,255,600	3,427,300	3,179,900	3,370,000
Ecuador	132,900	188,500	294,200	267,100	350,300	274,400	249,200
Brazil	2,043,500	2,044,600	2,403,000	2,020,700	2,196,600	2,252,900	1,954,700
Venezuela	300,000	171,400	25,300	22,400	24,500	280,600	340,500
Guiana:							
British	1,608,800	1,690,700	1,607,700	1,304,400	1,408,100	1,192,700	1,192,700
Dutch	441,600	632,500	689,200	640,000	663,000	621,000	792,600
French	1,806,400	1,859,700	1,858,900	2,360,800	2,135,500	2,143,800	2,229,100
Peru	1,329,200	516,100	829,000	514,500	514,500	514,500	455,900
Uruguay	25,000	50,000	31,700	51,900	91,600	91,600	91,600
Central America	1,252,500	1,513,400	1,910,700	2,107,800	3,018,800	2,630,100	4,657,400
Asia:							
Japan	2,948,200	3,072,400	2,748,900	2,773,000	3,321,600	3,616,900	3,903,600
China	4,500,000	4,500,000	4,500,000	4,500,000	8,647,300	9,352,100	3,658,100
Indo-China	....	....	....	31,800	65,600	65,600	55,000
Chosen (Korea)	3,000,000	2,593,000	2,283,000	2,170,800	3,047,500	1,993,600	4,399,100
Siam	51,800	48,600	53,200	166,200	327,600	327,600	56,500
India, British	11,722,900	11,950,200	12,087,700	10,383,600	10,598,500	10,358,600	10,718,400
East Indies, British	1,485,300	1,391,000	1,448,700	1,561,300	1,400,900	1,436,900	1,446,800
East Indies, Dutch	1,414,500	1,414,500	1,254,900	2,079,900	2,596,300	2,146,400	3,387,100
	347,377,200	380,288,700	402,503,000	412,966,600	442,476,900	454,059,100	455,239,100


1860
1861
1862
1863
1864
1865
1866
1867
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
VALUE
$460,000,000
435,000,000
410,000,000
385,000,000
360,000,000
335,000,000
310,000,000
285,000,000
260,000,000
235,000,000
210,000,000
185,000,000
160,000,000
135,000,000
110,000,000
85,000,000
60,000,000
35,000,000
FINE OUNCES
235,000,000
220,000,000
205,000,000
190,000,000
175,000,000
160,000,000
145,000,000
130,000,000
115,000,000
100,000,000
85,000,000
70,000,000
55,000,000
40,000,000
25,000,000

World's production of gold, 1904–1917—Continued.

Country.	1911	1912	1913	1914	1915	1916	1917
North America:							
United States	$96.890,000	$93 451,500	$88,884,400	$94,531,800	$101,035,700	$92,590 300	$83,750,700
Canada	9,762,100	12,648,800	16,598,900	15,983,004	18,977,901	19,235,000	15,200,000
Mexico	24,880,100	24,500,000	19,308,800	4,788,175	6,559,275	7,690,700	9,000,000
Cuba	20,000	....	....	....	....	....	....
Africa	191,538,400	211,850,600	207,326,500	201,996,796	217,851,898	222.948,900	214,614,000
Australasia	60,184,200	54,509,400	53,113,200	47,569,023	48,988,177	40,475 800	35,945,500
Europe:							
Russia, Finland and Siberia	32,151,600	22,199.000	26,508,700	28,586,392	26,322,746	22,500,000	18,000,000
Austria-Hungary	2,185,100	2,043,200	2,179,300	200,744	1,392,465	1,000,000	1,000,000
Germany	78,100	78,100	135,600	....	....	....	....
Norway	....	....	....	....	....	....	....
Sweden	2,000	20,300	17,600	54,304	25,323	12,200	10,000
Italy	44,800	11,000	17,200	32,145	.2,295	2,000	2,000
Spain and Portugal	2,400	2,300	2,300	2,336	661	....	....
Turkey	500	500	500	475	475	....	....
France	1,812,100	1,812,100	2,127,400	1,400,000	1,400,000	1,000,000	700,000
Great Britain	39.600	27,800	17,900	20,238	19,266	5,700	5,000
Serbia	251,100	251,100	328,000	116,000	....	....	....
South America:							
Argentina	$289,000	$107,300	$2,600	....	....	$15,300	$4,600
Bolivia and Chile	·362,500	175,000	336,884	$202,770	$814,418	301,000	315,000
Colombia	3,167,800	2,971,700	2,971,700	4,678,587	5,453,148	6,173,900	6,200,000
Ecuador	276,800	406,500	406,500	346,853	545,674	560,000	710,000
Brazil	3,834,500	3,570,600	2,254,700	2,139,803	2,424,515	2,890,000	2,958,000
Venezuela	364,800	623,500	419,040	564,220	1,395,349	1,269,900	637,000
Guiana:							
British	892,000	879,800	1,353,500	1,126,500	923,892	660,700	600,000
Dutch	523,400	407,300	470,400	503,400	449,054	438,200	400,000
French	2,229,100	3,050,600	3,050,600	1,959,793	1,959,793	1,600,000	1,500,000
Peru	492,300	492,200	912,280	1,022,125	1,109,891	1,267,400	1,300,000
Uruguay	70,600	111,000	29,900	15,276	11,836	12.000	10,000
Central America	3,360,400	3,030,400	2,721,700	2,393,190	2,970,271	3,517,600	3,122,000
Asia:							
Japan	4,118,600	4,467,000	3,614,400	4,679.358	5,386,066	5,185,600	4,562,200
China	3,314,600	3,658,900	3,658,900	3,658,900	2,804,692	3,100,700	3,600,100
Indo-China	74,700	74,700	74,700	66,419	43,659	65,600	50,000
Chosen (Korea)	2,889,400	2,852,600	3,582,500	3,309,870	3,739,477	4,122,400	4,444,000
Siam	56,500	56,500	56,500	....	....	....	....
India, British	11,054,100	11,055,700	12,178,000	11,378,400	11,522,457	11,206,500	10,756,800
East Indies, British	1,339,400	1,352,000	1,352,000	4,480,853	3,100,000	3,000,000	2,818,000
East Indies, Dutch	3,387,100	3,387,100	3,387,100				
Federated Malay States	....	....	282,400	269,147	351,527	327,900	342,300
Formosa	....	....	814,600	952,806	1,143,017	1,001,200	1,033,000
	461,939,700	466,136,100	460,497,204	439,029,702	468,724,918	454,176,500	423,590,200

For some foreign countries, owing to the difficulty of obtaining accurate statistics since the beginning of the European war, estimates have been made for 1914, 1915, 1916, and 1917; for a few other countries, because of lack of basis for estimates, the figures for preceding years have been repeated.

The figures given for the years 1904 to 1912, inclusive, are taken from the reports of the Director of the Mint. The statistics for 1913 to 1917, inclusive, were mainly adjusted in conference between the Mint and the Geological Survey.

The notable increase of total world's output of gold culminated in a new record of $468,724,918 in 1915.

The estimated world's production of gold in 1916 was $454,176,500, or about $14,500,000 less than in 1915, and it is estimated that the production in 1917 was $45,000,000 less than in 1915.

The present tendency, in the absence of discovery and development of new gold fields on a large scale, is toward a declining world's output of new gold, and this tendency is accentuated by the high cost of labor and supplies, which makes the operation of many gold mines unprofitable.

WORLD'S PRODUCTION OF SILVER.

Production of silver in the world, 1860–1917.

[The annual production from 1860 to 1872 is obtained from statistics for 5-year periods compiled by Dr. Adolph Soetbeer. For the period since 1872 the estimates are those of the Bureau of the Mint.]

Year.	Quantity (fine ounces).	Commercial value.	Year.	Quantity (fine ounces).	Commercial value.
1860	29,095,428	$39,337,000	1890	126,095,062	$131,937,000
1861	35,401,972	46,191,000	1891	137,170,000	135,500,200
1862	35,401,972	47,651,000	1892	153,151,762	133,404,400
1863	35,401,972	47,616,000	1893	165,472,621	129,119,900
1864	35,401,972	47,616,000	1894	164,610,394	104,493,000
1865	35,401,972	47,368,000	1895	167,500,960	109,545,600
1866	43,051,583	57,646,000	1896	157,061,370	105,859,300
1867	43,051,583	57,173,000	1897	160,421,082	96,252,700
1868	43,051,583	57,086,000	1898	169,055,253	99,742,600
1869	43,051,583	57,043,000	1899	168,337,452	101,002,600
1870	43,051,583	57,173,000	1900	173,591,364	107,626,400
1871	63,317,014	83,958,000	1901	173,011,283	103,806,700
1872	63,317,014	83,705,000	1902	162,763,483	86,264,700
1873	63,267,187	82,120,800	1903	167,689,322	90,552,200
1874	55,300,781	70,674,400	1904	164,195,266	95,233,300
1875	62,261,719	77,578,100	1905	172,317,688	105,113,700
1876	67,753,125	78,322,600	1906	165,054,497	111,721,100
1877	62,679,916	75,278,600	1907	184,206,984	121,577,100
1878	73,385,451	84,540,000	1908	203,131,404	108,655,100
1879	74,383,495	83,532,700	1909	212,149,023	110,364,400
1880	74,795,273	85,640,600	1910	221,715,673	119,727,000
1881	79,020,872	89,925,700	1911	226,192,923	122,143,800
1882	86,472,091	98,232,300	1912	224,310,654	137,883,800
1883	89,175,023	98,984,300	1913	225,410,085	136,153,700
1884	81,567,801	90,785,000	1914	160,626,019	88,845,500
1885	91,609,959	97,518,800	1915	178,850,500	92,809,100
1886	93,297,290	92,793,500	1916	161,177,900	106,022,800
1887	96,123,586	94,031,000	1917	163,992,700	135,048,000
1888	108,827,606	102,185,900			
1889	120,213,611	112,414,100		6,837,394,741	5,370,527,100

The figures for the world's production of silver in 1917 show that the United States and Canada produced about 94,000,000 ounces, or 57 per cent, and that Mexico, Central America, and South America yielded more than 49,000,000 ounces, or 30 per cent, so that approximately only 21,000,000 ounces of silver came from all other countries, mainly from Japan, Spain, and Australasia.

There was a considerable increase in the quantity of silver produced in Mexico in 1917, but the production from mines in the United States decreased about 2,700,000 ounces and that from Canada 3,300,000 ounces.

World's production of silver, 1905–1917, in fine ounces.

[Figures supplied by U. S. Bureau of the Mint.]

Country.	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
North America:													
United States	56,101,600	56,517,900	56,514,700	52,440,800	54,721,500	57,137,900	60,399,400	63,766,800	66,801,500	72,455,100	74,961,075	74,414,800	71,740,400
Canada	5,994,292	8,568,665	12,779,800	22,106,233	27,529,473	32,869,264	32,740,748	31,625,451	31,524,708	28,406,711	26,625,960	25,459,700	22,151,000
Mexico	65,040,865	55,225,268	61,147,203	73,664,027	73,942,432	71,372,194	79,032,440	74,640,300	70,703,828	27,546,752	39,570,151	22,838,400	31,214,000
Central American States	1,361,449	1,670,159	1,892,896	1,460,809	2,294,272	2,026,885	1,211,747	2,845,954	2,135,641	2,754,868	2,920,496	2,602,500	2,369,500
South America:													
Bolivia and Chile	3,494,851	3,149,395	5,222,358	5,806,117	5,548,154	6,490,163	4,555,043	4,049,856	3,932,594	789,685	3,870,065	4,402,100	4,107,400
Argentina	150,149	14,440	25,178	127,108	265,106	263,255	203,111	81,996	35,271	...	...	21,300	29,000
Brazil	...	...	...	...	...	...	47,222	40,610	28,364	76,685	21,523	22,000	25,000
Colombia	679,245	763,335	1,048,719	1,375,039	431,204	866,093	817,431	587,683	587,683	351,271	351,271	309,400	325,000
Ecuador	...	13,592	2,456	22,642	22,642	22,642	22,642	22,642	22,642	16,726	24,655	30,000	45,000
Peru	6,156,044	7,404,238	9,566,118	9,566,118	9,566,118	6,626,930	8,351,563	8,351,563	9,971,067	9,214,190	9,419,950	10,787,000	11,000,000
Guiana and Uruguay	...	...	...	...	...	...	...	724,235	51,111	...	...	8,500	8,000
Venezuela	...	...	...	104,626	204,958	208,043	436,903	122,303	...	...	...	...	3,300
Europe:													
Austria-Hungary	1,860,169	1,806,322	1,744,233	1,770,457	999,184	1,540,808	1,538,772	1,840,297	2,104,107	1,572,746	1,772,699	1,500,000	1,500,000
Germany	5,820,947	5,696,433	5,088,086	4,971,544	5,332,901	5,597,026	4,984,677	4,984,677	4,984,677	...	...	...	...
France	890,555	719,453	794,973	592,042	629,848	713,028	429,831	429,831	520,766	...	...	...	...
Great Britain	167,479	137,216	137,216	135,255	141,943	136,370	136,370	113,769	128,543	135,458	96,450	86,500	86,000
Greece	829,025	829,025	829,025	829,025	829,025	881,539	803,750	803,750	803,750	591,464	591,464	350,000	350,000
Italy	757,777	672,449	737,843	674,848	786,620	468,566	998,576	447,761	423,888	510,365	493,856	486,500	450,000
Norway	242,805	175,475	201,516	226,175	213,122	229,989	292,075	247,988	247,988	440,917	413,867	439,100	282,000
Spain and Portugal	4,000,000	4,064,532	4,097,035	4,175,674	4,767,091	4,546,430	4,270,324	5,358,448	4,437,637	4,434,417	4,567,454	4,517,800	4,500,000
Russia	204,960	166,183	132,122	132,122	132,122	140,632	477,140	200.094	...	...	638,403	550,000	500,000
Serbia	...	...	...	...	11,226	...	24,132	24,132	28,758	12,014	...	10,000	20,000
Sweden	24,765	32,375	29,761	35,728	29,373	19,823	19,823	32,202	58,969	33,511	24,230	37,900	35,000
Turkey	37,874	37,874	67,351	7,971	1,717,896	1,717,896	1,717,896	1,509,133	1,509,133	1,509,133	1,509,133	500,000	400,000
Australasia	15,035,486	13,909,371	17,949,099	17,175,099	16,359,284	21,545,828	16,578,421	14,737,944	18,128,577	3,573,077	4,295,755	4,063,300	4,070,800
Asia:													
British India	...	...	...	...	...	44,772	104,823	98,649	...	236,440	284,875	628,700	600,000
China	...	...	...	...	...	...	...	...	...	...	18,230	30,000	63,400
Chosen (Korea)	...	...	...	...	...	164,844	9,446	12,224	15,048	16,864	21,897	25,000	28,000
Dutch East Indies	182,889	248,240	335,454	571,953	465,980	465,980	465,980	465,980	465,980	...	...	...	...
Indo-China	...	...	...	...	...	...	...	...	...	1,767	1,056	1,000	1,000
Formosa	...	...	...	...	...	...	...	...	51,763	51,080	47,653	47,700	50,000
Japan	2,664,842	2,530,093	3,073,411	3,887,397	4,130,972	4,581,613	4,459,087	4,932,852	4,649,910	4,836,228	5,120,293	5,805,700	6,844,500
Africa	619,620	792,464	790,431	1,272,595	1,076,577	1,037,160	1,064,050	...	...	...	...	...	...
Belgian Kongo	...	...	...	...	...	...	...	...	1,454	4,770	4,770	11,000	10,300
Egypt	...	...	...	...	...	...	...	...	...	1,223	1,657	1,200	900
French East Africa	...	...	...	...	...	...	...	73,286	...	...	...	20,000	20,000
Madagascar	...	...	...	...	...	...	...						
Rhodesia	...	...	...	...	...	...	...	158,572	121,537	150,794	185,233	200,700	212,000
Transvaal, Cape Colony, Natal	...	...	...	...	...	...	...	984,672	933,191	901,763	996,379	968,900	950,000
Portuguese East Africa	...	...	...	...	...	...	...	...	...	...	...	1,200	1,200
	172,317,688	165,054,497	184,206,984	203,131,404	212,149,023	221,715,673	226,192,923	224,310,654	225,410,085	160,626,019	178,850,500	161,177,900	163,992,700

GOLD AND SILVER AND THE WAR.

The vast issues of bonds floated by most of the belligerent countries in the last three years have brought under consideration the desirability of larger production of gold and silver in order to sustain national credits, but this has not been possible under war conditions. It is not surprising that the world's production of gold decreased about $30,600,000 in 1917 nor that the output of silver was less by 61,500,000 ounces in 1917 than in 1913. It is astonishing that the decline was not more pronounced.

The full effects of the shortage of labor, the inefficiency of much of the labor available, lack and increased cost of transportation, and high costs of material did not reach a climax until 1918. The world's production of gold will undoubtedly be much less in 1918 than in 1917. The production of silver probably will not show so large a decline, for the larger output of silver from copper and lead ores in the United States, and from copper, silver, and lead mines in Mexico and South America, will partly offset decrease from siliceous ores in the United States and Canada.

War demands for silver, because of continued imperative needs in the Orient and because of the large increase in silver coinage to relieve gold currency and to pay armies and workers, have steadily increased. Commercial uses of silver in the arts and most industries have likely decreased but the use of silver nitrate has increased enormously. In order to stabilize the market for silver the maximum domestic price was fixed at 101½ cents per ounce, and under the Pittman Act passed by Congress in April, 1918, 350,000,000 silver dollars held in the United States Treasury were made available for remelting into bars and are being utilized by the United States and allied nations to settle trade balances in India, China, and other large silver-using countries. The quantity of silver required for this purpose was in excess of the total output of silver in the world in 1917, and it is stated that more than 75,000,000 silver dollars have been remelted up to October 1, 1918.

It is certain that the production of gold in South Africa, the United States, Russia, India, and Canada will materially decrease in 1918, and although there may be increase in Mexico and some South American countries such increase will be comparatively small and will not offset the loss in the principal gold-producing countries.

Many operators of gold mines produce ore of such grade that the margin of profit is very small and that margin depends entirely on the continuous supply and economical treatment of large quantities of ore. The difficulty in obtaining supplies and the decreased efficiency of the miners that could be obtained prevented the usual development in 1917. In consequence much of the ore milled in 1917 and in 1918 was that already broken in the mines and kept as a reserve. Prospecting and development of new mines and opening of new ore bodies in working properties have been retarded or altogether suspended. Moreover some properties have previously successfully mined and treated quantities of low-grade ore by mixing it with ore of higher grade. The higher cost of mining has in many cases rendered this course impossible lately, and the higher-grade ore was treated alone. This may result in leaving large quantities of ore which it will not be possible to hoist and mill at a profit in the future.

The gold-mining districts most affected by labor conditions were those adjacent to districts in which base metals were mined, as the products of the base-metal mines were sold at prices which enabled higher wages to be paid than owners of gold mines could afford to pay. Many gold mines have closed down and at others the best ore bodies are being exhausted at little or no profit.

The conditions at present hampering the mining of gold and the remedies for such conditions were investigated by organizations of mine owners such as the American Gold Conference, organized at Reno, Nev., in August, 1918, and the International Gold Conference, organized at Spokane, Wash., in September, 1918. It has been generally realized that it has not yet proved feasible to increase the price of gold or to change the quantity of gold in the coinage, but the operators of gold mines suggest that the gold industry can be aided by less revolutionary methods, which will not meet the same opposition. A report on the causes of the decrease in the production of gold and the future outlook of the industry has been made to the Secretary of the Interior by a joint committee from the Bureau of Mines and the Geological Survey under the chairmanship of Mr. Hennen Jennings.

In November, 1918, a committee, which includes the Director of the Mint, the Governor of Nevada, representatives of the War Trade Board and the War Industries Board, and prominent economists, was appointed to consider legislation to meet the problems which have tended seriously to impair the supply of gold from United States mines.

It is apparent that conditions imposed by the world war are responsible for much of the decrease in gold production, but in the United States there have been contributing causes which are more fully discussed in the separate State chapters of Mineral Resources for 1917 which relate to gold, silver, copper, lead, and zinc. Briefly stated, some of these minor causes are as follows:

In Alaska a decrease of about $1,300,000 of the total decrease of $2,580,000 in 1917 was due to the flooding of the Treadwell mines and to the lower gold content of the siliceous ore mined, which fell from an average per ton of $1.66 in gold in 1916 to $1.34 in 1917. Much of the decrease in yield of gold in Nevada in 1917 was due to the exhaustion of high-grade gold ore at Goldfield and of silver-gold ore at Tonopah. The quantity of ore treated in these two districts was 809,610 tons, only 28,986 tons less than in 1916, but the gold recovered decreased $1,153,000. Nearly all the decrease in yield of gold from Idaho was due to the exhaustion of gravels worked by dredging, and part of the decrease in Montana was due to the same cause and also to the strike at Butte, which reduced the quantity of gold-bearing copper ore mined and treated. California and Colorado were the two States most affected by the shortage of labor and the high cost of supplies, and much of the decrease in the production of gold in those States was caused by the smaller quantity of siliceous ores and old tailings treated by cyanidation. In Colorado the decrease in yield of gold was partly due to the smaller quantity of high-grade gold ores available for milling at Cripple Creek, Camp Bird, and other camps, and to the partial exhaustion of the high-grade deposits of gravel. It is difficult to make a correct division of the decrease of gold in the United States in 1917 between that caused by the war and that resulting from other causes. It is probable that at least $4,500,000 of the decrease of more than $10,000,000 was the result of conditions apart from the war.

MINES REPORT.

METHOD OF COLLECTING STATISTICS.

The first table in this report presents the final official figures of the production of gold and silver in the United States in 1917 as agreed upon by the Bureau of the Mint and the United States Geological Survey. With the comparatively unimportant exceptions of domestic gold and silver contained in ores and mattes exported for reduction during the year, these figures record the actual production of gold and silver bullion from domestic ores in marketable form as metals, either refined or unrefined.

Owing to the difficulty of tracing this total gold and silver production back to its origin by States, counties, and mining districts, however, the Geological Survey attacks this problem of distribution by systematic investigation of the mine production of ores containing gold and silver during the calendar year and of the output of the placer mines. In this way the state of the mining industry is studied in detail, and classification of output by methods of production and by kinds of ore, as well as by mining districts, is obtained. The resulting figures form the basis of the mines report.

Of the two plans outlined for ascertaining the gold and silver production of the United States it may be said that the one is a measure of the mining industry and the other a measure of the metallurgical industry; that the one reports the production and recoverable content of mine output and the other the metal actually recovered in marketable form. The two methods will not produce exactly corresponding results, nor should they be expected to do so.

The figures of the reports of the Mint and of the mines reports for a period of years sufficiently long to compensate for overlap or lag should agree within allowable limits of error due to the complex problem involved.

For the last 13 years in which complete statistics have been gathered by both methods the final figures have been as follows:

Production of gold and silver in the United States, 1905–1917, according to mint and to mine returns.

Year.	Mint.		Mine.	
	Gold.	Silver.	Gold.	Silver.
		Ounces.		*Ounces.*
1905	$88,180,700	56,101,600	$88,159,881	56,272,496
1906	94,373,800	56,517,900	97,219,645	57,362,455
1907	90,435,700	56,514,700	87,471,136	52,500,104
1908	94,560,000	52,440,800	91,914,891	50,878,140
1909	99,673,400	54,721,500	99,438,144	57,315,677
1910	96,269,100	57,137,900	94,933,778	57,598,509
1911	96,890,000	60,399,400	97,054,791	61,108,791
1912	93,451,500	63,766,800	92,880,467	66,041,506
1913	88,884,400	66,801,500	89,987,888	71,200,237
1914	94,531,800	72,455,100	92,703,757	69,633,769
1915	101,035,700	74,961,075	99,605,314	72,308,878
1916	92,590,300	74,414,802	92,822,430	78,875,176
1917	83,750,700	71,740,362	82,032,745	70,665,531
	1,214,627,100	817,973,439	1,206,224,867	821,821,269

These figures show, according to Mint reports, a total excess of gold for the 13 years of $8,402,233, or a difference of not quite 0.7 per cent, and a total deficit of silver of only 3,847,830 ounces, or a difference less than 0.47 per cent. The figures for Alaska placers are not considered to be so closely approximate as the above agreement for gold, hence the differences for the United States proper are probably even lower. It is thought that those small differences are fully accounted for in the detailed discussions of the subject in previous reports of this series. For figures of any one year an excess of mining over smelting and refining is indicated by larger returns in the mines reports for gold or silver or both and opposite relations or excess of smelting and refining and drawing upon stocks are indicated by larger returns in the Mint report.

UNITS OF MEASUREMENT.

In measurement of ores and concentrates the short ton of 2,000 pounds is used throughout. The price of gold is fixed by law at $20.67+ per fine ounce. The annual average prices for silver from 1865 to 1917, inclusive, based on the equivalent New York value of a fine ounce with exchange at par, are given elsewhere in this report. (See p. 607.) The average commercial prices (or dealers' prices) for silver 0.999 fine at New York are those quoted from day to day on the market and run uniformly somewhat below the prices as given elsewhere by years.

PRODUCTION OF GOLD AND SILVER REPORTED FROM THE MINES.

The following table gives the quantity and value of the output of recoverable gold and silver (mine production) by States reported from the producing mines in 1917 to the United States Geological Survey. The increase or decrease of production shows results by comparison with the corresponding Survey mine figures for 1916.

Mine production of gold and silver in the United States in 1917.

State or Territory.	Gold.		Silver.		Increase or decrease.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	Gold.	Silver (fine ounces).
Alabama	109.42	$2,262	11	$9	− $6,388	− 42
Alaska	709,049.45	14,657,353	1,239,150	1,021,060	− 2,584,360	− 140,021
Arizona	245,173.83	5,068,193	6,983,913	5,754,744	+ 1,082,634	− 228,126
California	971,733.00	20,087,504	1,775,431	1,462,955	− 1,323,237	− 788,923
Colorado	760,901.22	15,729,224	7,304,353	6,018,787	− 3,424,597	− 352,191
Georgia	333.26	6,889	46	37	− 15,650	− 28
Idaho	38,932.64	804,809	12,029,338	9,912,175	− 311,001	− 271,535
Illinois	....	....	7,186	5,921	....	+ 1,502
Maryland New-Hampshire, Pennsylvania and Vermont	6.62	137	1,709	1,409	+ 137	− 2,312
Michigan	....	....	688,551	567,366	....	− 28,089
Missouri	....	....	61,586	50,747	....	− 67,864
Montana	170,147.11	3,517,253	13,128,142	10,817,589	− 1,033,241	− 3,366,224
Nevada	336,664.26	6,959,468	11,269,969	9,286,454	− 1,906,769	− 2,567,556
New Mexico	51,478.64	1,064,158	1,394,365	1,148,957	− 318,322	− 371,909
North Carolina	589.55	12,187	1,110	915	− 14,050	+ 447
Oklahoma	....	....	....	....	....	− 606
Oregon	72,165.73	1,491,798	125,656	103,541	− 410,381	− 105,686
Philippine Islands	68,119.81	1,408,161	4,019	3,312	− 106,039	− 13,624
Porto Rico	4.84	100	....	....	− 500	....
South Carolina	52.39	1,083	3	2	+ 763	− 25
South Dakota	356,244.77	7,364,233	186,765	153,894	− 96,411	− 28,440
Tennessee	257.65	5,326	99,053	81,619	− 413	+ 4,352
Texas	1.06	22	595,789	490,930	− 392	− 57,666
Utah	162,305.67	3,355,156	13,479,133	11,106,806	− 219,791	+ 226,096
Virginia	64.97	1,343	4,518	3,723	+ 458	+ 3,735
Washington	23,816.17	492,324	282,320	232,632	− 85,331	− 52,801
Wyoming	181.98	3,762	3,415	2,814	− 16,804	− 2,109
	3,968,334.04	82,032,745	70,665,531	58,228,398	−10,789,685	− 8,209,645
Increase or decrease in value	....	....	....	....	−10,789,685	+$6,828,532

A decrease in production of gold from mines of the United States of $10,789,685 is shown for 1917, following a decrease of $6,782,884 in 1916. A decrease of 8,209,645 ounces of silver is shown, following an increase of 6,506,298 ounces in 1916.

The principal gold-producing States ranked as follows in 1917: California, Colorado, Alaska, South Dakota, Nevada, and Arizona, and these six States together made nearly 85 per cent of the total output. The only notable increase was Arizona, which produced about $1,080,000 more in 1917 than in 1916. The most notable decrease in gold was $3,424,597 in Colorado, $2,584,360 in Alaska, $1,906,769 in Nevada, $1,323,237 in California, and $1,033,241 in Montana. Every State that yielded more than $50,000 in gold, with the exception of Arizona, had a decreased output in 1917.

The principal silver-producing States in 1917 in order of output were Utah, Montana, Idaho, Nevada, Colorado, and Arizona, and these six States together produced 90 per cent of the total for the United States. There was no large increase in 1917 and only five States had an increased output, of which Utah had the largest—226,000 ounces. There was large decrease in output of silver—2,567,556 ounces in Nevada, 3,366,224 ounces in Montana, 788,923 ounces in California, and 352,191 ounces in Colorado.

About $35,400,000, or 43 per cent, of the entire output of gold in the United States in 1917 was produced by 25 companies. The largest producer was the celebrated Homestake mine in South Dakota. Seventeen of the larger properties produced the gold from dry or siliceous ores, 3 produced it from gravels by dredging, 4 recovered the gold in the treatment of copper ores, and 1 from lead ores. Deducting the output of gold of the large producing operators, it is shown that about $46,800,000 came from the operation of about 5,000 placer and deep mines, many of which produced between $100,000 and $600,000 each. Hundreds of mines, especially placer properties in California, Oregon, Idaho, Alaska, Arizona, and the Applachian States, yielded very small quantities of gold.

Larger producers of gold in the United States in 1917, in order of output.

Operator.	State.	Mining district.	Source of gold.
Homestake Mining Co	South Dakota	Whitewood	Dry or siliceous ores.
Yuba Consolidated Goldfields	California	Marysville	Dredging gravels.
Cresson Consolidated Mining Co	Colorado	Cripple Creek	Dry or siliceous ores.
Portland Gold Mining Co	do	do	Do.
Alaska Gastineau Mining Co	Alaska	Juneau	Do.
Empire Mines	California	Grass Valley	Do.
United Eastern Mining Co	Arizona	Oatman	Do.
Vindicator Consolidated Gold Mining Co	Colorado	Cripple Creek	Do.
Goldfield Consolidated Mines Co	Nevada	Goldfield	Do.
North Star Mines	California	Grass Valley	Do.
Yukon Gold Co	Alaska	Ruby and Iditarod	Dredging gravels.
Utah Copper Co	Utah	West Mountain	Copper ores.
Argonaut Mining Co	California	Grass Valley	Dry or siliceous ores.
Tomboy Gold Mines Co	Colorado	Upper San Miguel	Do.
Liberty Bell Gold Mining Co	do	do	Do.
Marysville Dredge Co	California	Marysville	Dredging gravels.
Plymouth Consolidated Mining Co	do	Mother Lode	Dry or siliceous ores.
Kennedy Mining Co	do	Jackson	Do.
Barnes King Mining Co	Montana	Ottawa	Do.
Alaska United Mining Co	Alaska	Juneau	Do.
United Verde Copper Co	Arizona	Verde	Copper ores.
Calumet & Arizona Mining Co	do	Turquoise	Do.
United States Mining Co	Utah	West Mountain	Lead ores.
Anaconda Copper Mining Co	Montana	Summit Valley	Copper ores.
Tom Reed Gold Mines Co	Arizona	Oatman	Dry or siliceous ores.

The largest output of silver was that of the Anaconda Copper Co. from copper ores. The Hercules Mining Co., of Idaho, which had the second largest output of silver, and the Bunker Hill & Sullivan Mining Co., the fourth largest producer, derived the silver from lead ores. The Tonopah Belmont Development Co., which held third place, was the largest producer from siliceous ores. Six of the 25 mines enumerated recovered silver from copper ore, 10 from lead ore, 8 from dry or siliceous ore, and 1 from zinc-lead ore. Several mines yielded more silver than the Presidio mine, in Texas, but it was the largest producer of silver from ore that contained no appreciable quantity of any other metal. The approximate output of the 25 properties was 35,410,000 ounces, or about 50 per cent of the total production of silver in the United States in 1917.

Larger producers of silver in the United States in 1917, in order of output.

Operator.	State.	Mining district.	Source of silver.
Anaconda Copper Mining Co.	Montana	Summit Valley	Copper ores.
Hercules Mining Co.	Idaho	Leland	Lead ores.
Tonopah-Belmont Development Co.	Nevada	Tonopah	Dry or siliceous ores.
Bunker Hill & Sullivan Mining Co.	Idaho	Yreka	Lead ores.
Butte & Superior Mining Co.	Montana	Summit Valley	Lead-zinc ores.
Chief Consolidated Mining Co.	Utah	Tintic	Lead ores.
United Verde Copper Co.	Arizona	Verde	Copper ores.
Tonopah Mining Co.	Nevada	Tonopah	Dry or siliceous ores.
Hecla Mining Co.	Idaho	Leland	Lead ores.
Tonopah Extension Mining Co.	Nevada	Tonopah	Dry or siliceous ores.
Federal Mining & Smelting Co.	Idaho	Hunter	Lead ores.
Caledonia Mining Co.	do.	Yreka	Do.
Calumet & Arizona Mining Co.	Arizona	Warren	Copper ores.
Silver King Coalition Mining Co.	Utah	Uintah	Lead ores.
Kennecott Copper Co.	Alaska	Chitina	Copper ores.
Jim Butler Tonopah Mining Co.	Nevada	Tonopah	Dry or siliceous ores.
Copper Queen Consolidated Mining Co.	Arizona	Warren	Copper ores.
Nevada Wonder Mining Co.	Nevada	Wonder	Dry or siliceous ores.
Green Hill Cleveland Mining Co.	Idaho	Leland	Lead ores.
North Butte Mining Co.	Montana	Summit Valley	Copper ores.
Iron Blossom Consolidated Mining Co.	Utah	Tintic	Lead ores.
United States Mining Co.	do.	West Mountain	Do.
West End Consolidated Mining Co.	Nevada	Tonopah	Dry or siliceous ores
Smuggler Union Mining Co.	Colorado	Upper San Miguel	Do.
Presidio Mining Co.	Texas	Shafter	Siliceous (silver) ores.

MINE PRODUCTION OF GOLD AND SILVER, BY STATES.

ALASKA.

It is estimated that the total production of gold in Alaska from earliest mining, in 1880, to the end of 1917 has been $292,758,000, of which $207,142,992 has come from placers. The total production of silver has been 7,541,600 fine ounces, of which 4,607,493 ounces was recovered from copper ores and 1,703,323 ounces from the refining of placer gold.[1]

Gold.—The mine production of gold in Alaska in 1917 was $14,657,353, or about $2,580,000 less than that of 1916. The yield from siliceous ores decreased from $5,912,736 in 1916 to $4,581,453 in 1917; the yield from copper ores increased from $188,977 in 1916 to $265,900 in 1917; the placer output in 1917 was $9,810,000 against $11,140,000 in 1916. Thirty-six dredges produced $2,500,000 of the placer gold, which was $179,000 less than the yield from dredging in 1916.

---

[1] U. S. Geol. Survey Mineral Resources, 1917, pt. 1, pp. 131-136, 1918.

Of the productive gold lode mines, 10 were in southeastern Alaska, 3 on Prince William Sound, 4 in Kenai Peninsula, 5 in Willow Creek district, and 9 in Fairbanks district. The 10 deep gold mines in southeastern Alaska yielded more than 92 per cent of the gold derived from siliceous ores.

The 3,414,664 tons of siliceous ores treated in 1917 yielded an average of $1.37 in gold and silver a ton, and the 659,951 tons of copper ore contained $1.70 in gold and silver a ton and had a copper content of 6.4 per cent.

More than 31 per cent of the total output of gold in Alaska came from gold lode mines in 1917, against 34 per cent in 1916, 36 per cent in 1915, 31 per cent in 1914, 31 per cent in 1913, and 29 per cent in 1912. The 610 placers operated in 1917 yielded approximately 5,900,000 cubic yards of auriferous gravel, of which the dredges handled about 3,700,000 cubic yards and made an average recovery of 67.5 cents a yard in 1917, against 69 cents a yard in 1916, 51 cents a yard in 1915, and 52 cents a yard in 1914. The estimated total recovery of gold by dredging for the period 1903–1917, inclusive, is $17,610,000.

The only new placer-bearing areas reported in 1917 were in the Kuskokwim and Goodnews Bay districts.

Silver.—The mine production of silver in Alaska in 1917 was 1,239,150 fine ounces, against 1,379,171 ounces in 1916. The copper mines produced 1,041,153 ounces, a decrease of 165,968 ounces. The siliceous ores yielded 133,587 ounces in 1917, against 110,050 ounces in 1916 and 91,341 ounces in 1915, and the placers yielded 64,410 ounces in 1917, against 62,000 ounces in 1916.

ARIZONA.

Gold.—The mine production of gold in Arizona in 1917 was $5,068,193, which was $1,082,634, or 27 per cent, more than in 1916. Placers contributed only $17,214, which came from small mines in Yuma, Pima, Maricopa, and Yavapai counties. The deep mines produced $5,050,979, of which 53 per cent came from dry or siliceous ores mined chiefly in Mohave, Yavapai, and Cochise counties, and 40 per cent was contained in copper ores mined chiefly in Cochise and Yavapai counties. Mohave County had a gold output of $2,463,178, an increase of more than $1,400,000; Cochise County produced $1,149,782 and Yavapai County $1,023,464. The gold recovered from ores treated at gold and silver mills represented 49 per cent of the total output, against 36 per cent in 1916, and crude ores shipped to smelters contained nearly 39 per cent. The crude copper ores mined and smelted directly (without previous concentration) contained an average gold content of 46 cents a ton.

Silver.—The mine production of silver decreased from 7,212,039 fine ounces in 1916 to 6,983,913 ounces in 1917. Of this production 5,214,411 ounces came from copper ores, 848,500 ounces from dry or siliceous ores, 553,544 ounces from lead ores, 190,033 ounces from lead-zinc ores, and smaller quantities from zinc, copper-zinc, and copper-lead ores. Cochise County produced 2,707,220 ounces in 1917, of which 1,806,040 ounces came from copper ores and 522,688 ounces from siliceous ores. The silver output of Yavapai County, which increased from 1,735,302 ounces in 1916 to 2,207,583 ounces in 1917, was mainly derived from copper ores. Bullion recovered from gold and silver ores, almost all by cyanidation, yielded 254,353 ounces of silver. Concentrates contained 1,271,890 ounces and crude ore shipped to smelters contained 5,312,292 ounces, or 76 per cent of the total output of silver.

CALIFORNIA.

Gold.—The mine production of gold in California in 1917 was $20,087,504. The decrease of $1,082,634 was due to a smaller production from deep-mine operations.

In 1917 the deep mines produced $11,013,474 (a decrease of $1,821,610), of which gold-quartz ores yielded 93 per cent and copper ores 6.1 per cent. California placers in 1917 produced $9,074,030 in gold, or $498,373 more than in 1916. Of the placer production $8,313,527 was recovered by dredging. The total dredge production from 1896 to the end of 1917 has been $95,193,985 and the yield of gold by dredges was equal to 41 per cent of the total yield of gold for 1917. The Yuba County dredges, 12 in number, made the largest output of gold, the value being $3,659,211, an increase of $519,061. Sacramento County, with 12 dredges working, made an output of $1,913,504, an increase of $84,026. In Butte County (including Oroville and other districts) 11 dredges produced $898,141 in gold, or $312,733 less than in 1916. Dredges were also operated in Calaveras, Eldorado, Merced, Stanislaus, Placer, Shasta, Siskiyou, and Trinity counties.

Five of the 26 counties in California which reported mine production of gold had a yield of more than $1,000,000 in 1917, as follows: Nevada, $3,682,947; Amador, $3,664,164; Yuba, $3,677,673; Sacramento, $1,919,581; Calaveras, $1,471,442. Of these Yuba and Sacramento counties obtained most of their yield by dredging, Amador and Calaveras are on the Mother Lode, and Nevada County produced mainly from siliceous ores of the Grass Valley district. The five Mother Lode counties—Amador, Calaveras, Eldorado, Mariposa, and Tuolumne—whose output is mainly gold milling ores, produced $3,202,212 in gold from mill bullion and $1,888,961 from concentrates in 1917, against a recovery of $3,719,649 from mill bullion and $2,092,169 from concentrates in 1916.

Silver.—The mine production of silver in California in 1917 was 1,775,431 fine ounces, a decrease of 788,923 ounces. More than 36 per cent of the output, or 625,000 ounces, came from the copper ores of Shasta County. Copper ores yielded 882,480 ounces. Siliceous ores yielded 139,492 ounces, silver-lead ores, silver ores, and lead ores 726,174 ounces, and placers the remainder. The only counties producing more than 100,000 ounces of silver in 1917 were Shasta, Inyo, Calaveras, and San Bernardino. About 85 per cent of all the silver was recovered from crude ores sent to smelters.

COLORADO.

Gold.—The total mine production of gold in Colorado in 1917 was $15,729,224, a decrease of $3,424,597. The Cripple Creek district, with a decrease of $1,724,703, produced $10,394,847 in gold, which was 66 per cent of the State output of gold from all sources. During

1917 the Roosevelt tunnel was driven 1,746 feet. The total length of the tunnel from portal to breast at the end of 1917 was 24,000 feet.

The San Juan region, in Dolores, La Plata, Ouray, San Juan, and San Miguel counties, produced $2,451,292, a decrease of $589,988. Lake County yielded $1,175,219, a decrease of $545,221, and there were also decreases in Boulder, Clear Creek, Gunnison, Gilpin, La Plata, Ouray, Chaffee, and San Juan counties. Siliceous and dry ores, which amounted to 74 per cent of all the ore sold or treated, yielded 74 per cent of the total output of gold. Slightly less than 3 per cent came from lead ore, 4 per cent from placers, about 1 per cent from copper ore, and the remainder from other classes of ore. The placer production in 1917 was $661,028, a decrease of $51,896. Summit County produced nearly 82 per cent and Lake County 17 per cent of the placer gold. Dredges in these two counties recovered more than 98 per cent of the placer gold.

Silver.—The mine production of silver in Colorado in 1917 was 7,304,353 fine ounces, a decrease of 352,191 ounces. Lake County, principally Leadville, produced 2,184,000 ounces, a decrease of 463,560 ounces. San Miguel County produced 779,364 ounces, a decrease of 32,677 ounces. There was a considerably larger production of silver from Ouray, San Juan, Clear Creek, Chaffee, and Pitkin counties and decreased output from Gilpin and La Plata counties. Siliceous and dry ores yielded 66.6 per cent of the silver recovered, lead ores 16 per cent, lead-zinc ores 12.7 per cent, and copper ores 2.5 per cent. The remainder came from placers, zinc ores, and copper-lead ores.

IDAHO.

Gold.—The mine production of gold in Idaho in 1917 was $804,809, a decrease of $311,001. The total production of gold from Idaho from the discovery of placer gold in 1863 to the end of 1917 is estimated at $130,910,969 by C. N. Gerry.[1]

Boise and Idaho counties were the largest producers of gold and yielded about 53 per cent of the total output. The lode mines produced gold valued at $669,578. The placer mines produced $135,231 in gold in 1917, of which $59,447 was won by dredging. The total output of gold recovered by dredges from 1897 to the end of 1917 has been $3,781,503. Of the total gold in 1917 about 17 per cent came from placers, 64 per cent from siliceous ores, 7 per cent from copper ores, and the remainder from lead and lead-zinc ores.

Silver.—The mine production of silver in Idaho in 1917 was 12,029,338 fine ounces, or 271,535 ounces less than in 1916. The total yield of silver from Idaho for the period 1863 to 1917, inclusive, is 224,706,000 fine ounces.[1]

There was a decrease of 3 per cent in the output of silver from Shoshone County, which yielded 93.4 per cent of the total quantity of silver in 1917, 95 per cent in 1916 and 1915, and 98 per cent in 1914. Lead ores contained 67 per cent of the output of silver and lead-zinc ores 30 per cent. Crude ore shipped, which averaged 13.80 ounces of silver a ton, supplied nearly 33 per cent of the silver, and concentrates, which averaged 19.19 ounces of silver a ton, contained nearly 67 per cent of the total silver. Inability to handle and smelt all the ores mined had the effect of curtailing the production of silver.

---

[1] U. S. Geol. Survey Mineral Resources, 1917, pt. 1, p. 457, 1918.

MARYLAND, PENNSYLVANIA, NEW HAMPSHIRE, AND VERMONT.

A small production of gold and silver was reported by copper mines in Frederick County, Md., in 1917, although work was also done on prospects in Montgomery County, Md. A small quantity of gold and about 500 ounces of silver were obtained from copper ores and old slag shipped from mines in Orange County, Vt.

MICHIGAN.

Silver.—The copper mines of Michigan produced 688,551 fine ounces of silver in 1917, against 716,640 ounces in 1916. The silver was mainly derived from the electrolytic treatment of 70,329,000 pounds of copper. The average recovery of silver per ton of "rock" treated was 0.21 ounce a ton. Of the total output of silver 558,465 ounces came from mines in Houghton County.

MISSOURI, OKLAHOMA, ILLINOIS, AND KENTUCKY.

Silver.—The lead and zinc mines of the Central States produce no gold and only a comparatively small quantity of silver. Nearly all the silver is a by-product from the refining of lead from concentrates of lead ores mined in southeastern Missouri. The total yield of silver from Missouri in 1917 was 61,586 fine ounces, which, with the exception of a few ounces recovered from copper ore, was derived from lead recovered from 76,222 tons of galena concentrates. The average recovery was slightly less than 0.81 ounce of silver per ton of concentrate smelted.

The lead-zinc fluorspar deposits of the Kentucky-Illinois field carry silver, and from the lead concentrates shipped from Illinois in 1917 a recovery of 7,186 ounces was recorded, against 5,684 ounces in 1916. The average silver content per ton recovered from lead concentrates from Illinois in 1917 was 5.80 ounces. No silver ore was shipped from the Criswell mine, near Byars, McClain County, Okla., in 1917.

MONTANA.

Gold.—The mine production of gold in Montana decreased from $4,550,494 in 1916 to $3,517,253 in 1917. The placer yield was $467,063, a decrease of $256,096. Lewis and Clark County had the largest total output, $872,529. Most of the placer gold was recovered by one company, which operated three dredges in Alder Gulch, in Madison County. Deer Lodge County produced $456,588, chiefly from siliceous ores, and Silver Bow County $690,801, chiefly from copper ores. At amalgamation and cyanidation plants $1,383,097 in gold was produced, or an average recovery of $4.10 per ton of ore and tailings treated. Ore treated at concentration mills yielded concentrates containing $675,560, or 37 cents a ton, and crude ore shipped to smelters contained $982,558 in gold, or an average of $1.95 a ton.

Silver.—Montana mines produced 13,128,142 fine ounces of silver in 1917, a production nearly 20 per cent less than in 1916. The copper ores yielded 8,911,389 ounces (an average of 1.84 ounces per ton), of which Silver Bow County (Butte) supplied 8,791,855 ounces. The lead-zinc ores produced 2,386,824 ounces, of which Silver Bow

County supplied 2,183,662 ounces. The dry or siliceous ores produced 954,477 ounces, of which Granite County supplied 394,586 ounces. Nearly all the silver from zinc ore, 378,239 ounces, came from Silver Bow County.

NEVADA.

Gold.—The mine production of gold in Nevada in 1917 was $6,959,468, against $8,866,237 in 1916. The production in 1917 from mines in Esmeralda County was $1,986,001, a decrease of nearly $700,000. The Goldfield district yielded $1,900,082 in gold in 1917, against $2,651,158 in 1916. Nye County produced $2,007,234, of which Tonopah yielded $1,539,529. The counties having a substantial increase in gold were White Pine and Lincoln. Sixty-six per cent of the decrease in output of gold was due to smaller yield from Goldfield and Tonopah.

Silver.—There was a decrease in the mine production of silver in Nevada in 1917, the total being 11,269,969 fine ounces, against 13,837,525 ounces in 1916. Nye County (almost wholly from the Tonopah district) again led in output with 7,172,642 ounces, which was about 1,700,000 ounces less than in 1916. Churchill County, with 887,765 ounces, Humboldt County, with 859,837 ounces, and Lincoln County, with 523,399 ounces, were the other counties which had an output exceeding 500,000 ounces. Dry or siliceous ores yielded all but 1,093,252 ounces of the output of silver and 90 per cent of this yield was recovered by cyanidation.

NEW MEXICO.

Gold.—The mine production of gold in New Mexico in 1917 was $1,064,158, against $1,382,480 in 1916 and $1,461,105 in 1915. Mills in the Mogollon district, Socorro County, produced $258,620; Grant County, $404,446; and Colfax County, $348,733.

Copper ores, chiefly from Grant County, contained $224,829, and dry and siliceous ores yielded $816,469. The output from other kinds of ore was very small, and the placer output was only $12,179.

Silver.—The mine production of silver in New Mexico decreased from 1,766,274 fine ounces in 1916 to 1,394,365 ounces in 1917. Socorro County produced 859,892 fine ounces, or about 62 per cent, chiefly from siliceous ores from the Mogollon district, the remainder from mixed ores of the Magdalena district. The output of silver from Grant County decreased from 549,907 fine ounces in 1916 to 487,558 ounces in 1917, and most of this yield came from the Lordsburg district. Dry and siliceous gold and silver ores, chiefly from Grant, Sandoval, and Socorro counties, yielded 69.3 per cent of the total; copper ores, chiefly from Grant, Socorro, and Santa Fe counties, yielded 23 per cent. The remainder of the production was from lead, lead-zinc, and copper-lead ores, mainly from the Central and Magdalena districts.

OREGON.

Gold.—The mine production of gold from Oregon decreased more than 21 per cent, being $1,491,798 in 1917, against $1,902,179 in 1916. The output in 1916 was the largest recorded by the Survey for 13 years. The decrease in 1917 was mainly due to the deep mines, which yielded only $764,432, or $265,230 less in 1917 than in 1916.

The output from deep mines was almost entirely from siliceous ores. The placer mines of the State produced $727,366, a decrease of $145,151. The three dredges in the Cracker Creek district in Baker County and one dredge in Grant County produced $618,922, and a few drift mines, hydraulic and surface placers in Baker, Jackson, Crook, Josephine, and Malheur counties produced the remainder of the placer gold. Baker County, with a yield of $1,228,199, and Grant County with a yield of $137,720, were the only counties which produced more than $100,000 in gold.

Silver.—The mine production of silver in Oregon in 1917 was 125,656 fine ounces, a decrease of 105,686 ounces. Of the total production 87,121 ounces came from siliceous ores, 31,375 ounces from copper ores, and 7,160 ounces from placer bullion.

SOUTH DAKOTA.

The total value of the production of gold in South Dakota from 1876 to the end of 1917 is given by Charles W. Henderson, of the United States Geological Survey, as $207,518,800, and the total output of silver for the same period as 6,434,500 fine ounces.[1]

Gold.—The mine production of gold in South Dakota in 1917 was $7,364,233, against $7,460,644 in 1916. The output was almost wholly from siliceous milling ores of low grade, of which about 64 per cent was recovered by amalgamation and the remainder by cyanidation. The Homestake mines and mills were operated continuously and produced $6,619,573 in bullion from 1,677,623 tons of ore treated. The Golden Reward, Mogul, and Trojan mills were also operated steadily. The small yield of placer gold came from Lawrence and Pennington counties.

Silver.—The mine output of silver, derived mainly from refining the gold bullion produced, was 186,765 fine ounces, or 28,440 ounces less than in 1916.

SOUTHERN APPALACHIAN STATES.

The total production of gold from 1799 to the end of 1917 in the southern Appalachian States, as shown from data compiled by the Bureau of the Mint and the United States Geological Survey, has been $51,007,344. The figures credit Alabama with $765,539, Georgia with $17,817,876, Maryland with $71,405, North Carolina with $23,626,782, South Carolina with $5,181,429, Tennessee with $248,144, and Virginia with $3,296,169.

Gold.—The combined mine production of gold in the southern Appalachian States in 1917 was $29,156, against $64,370 in 1916. North Carolina led with $12,187; Georgia was next with $6,889; Tennessee, $5,326; Alabama, $2,262; Virginia, $1,343; South Carolina, $1,083; and Maryland, $66. The gold produced in Tennessee was from copper ores of the Ducktown district. The production of gold from 29 placers amounted to $6,954. Copper ores, mainly from Maryland, North Carolina, and Tennessee, yielded about 430 ounces of gold, and siliceous ores from Alabama, Georgia, North Carolina, and South Carolina yielded only 574 ounces in 1917, against 1,985 ounces from these States and Virginia in 1916.

---

[1] U. S. Geol. Survey Mineral Resources, 1917, pt. 1, p. 154, 1918.

TEXAS.

Gold.—The total output of gold from Texas mines from 1885 to the end of 1917 is given by Charles W. Henderson as $43,500.[1]

The yield of gold has been very small and has been mainly a by-product. The output of gold decreased from $414 in 1916 to $22 in 1917.

Silver.—The total production of silver in Texas from 1885 to 1917, inclusive, has been 13,677,100 ounces, according to Henderson.[1]

The mine production for 1917 was 595,789 fine ounces, against 653,455 ounces in 1916. The greater part of the silver continued to come from the Presidio silver mine and cyanidation mill in the Shafter district, Presidio County. The silver contained in copper ores shipped in 1917 amounted to 1,699 ounces and that in lead ores to 962 ounces.

UTAH.

Gold.—The total output of gold in Utah from 1864 to 1917, inclusive, is given by V. C. Heikes, of the United States Geological Survey, as $93,119,333.[2]

The mine production of gold decreased from $3,574,947 in 1916 to $3,355,156 in 1917. The largest part of the gold was contained in ores produced in Salt Lake County, and amounted to $2,268,684. Juab County ranked next with $843,609, against $856,474 in 1916. The Bingham district, with its large output of copper and other ores, produced $2,241,152 in gold in 1917, and the Tintic district, partly in Juab County and partly in Utah County, produced $868,547. The production of placer gold in 1917 was only $112, and the output recovered by cyanidation and amalgamation was about $2,900. The greater part of the Utah gold (58.5 per cent) was derived from copper ores mainly mined in Salt Lake and Juab counties; lead and lead-zinc ores contained 29 per cent.

Silver.—The total output of silver in Utah from 1864 to 1917, inclusive, has been 366,020,500 fine ounces, according to Heikes.[2]

The mine production of silver in Utah in 1917 was 13,479,133 ounces, an increase of 226,096 ounces. The largest production was from Juab County, credited with 4,988,005 ounces (mainly from lead ores), against 4,892,439 ounces in 1916. Salt Lake County had the next largest output, 3,769,884 ounces (from copper, lead, and lead-zinc ores), against 3,863,264 ounces in 1916. Of the Salt Lake County output of silver, the Bingham district produced 74 per cent. The Tintic district, in Juab and Utah counties, yielded 5,558,763 ounces (mainly from lead ores); and the Park City region, in Summit and Wasatch counties, produced 2,937,438 ounces, mainly from lead and lead-zinc ores. Altogether the lead ores of Utah yielded 7,490,650 ounces of silver in 1917, the copper ores 2,225,119 ounces, the lead-zinc ores 1,329,531 ounces, and the dry or siliceous ores 2,340,537 ounces. The crude ore smelted in 1917 contained 10,498,129 ounces and concentrates contained 2,469,804 ounces.

---

[1] U. S. Geol. Survey Mineral Resources, 1917, pt. 1, 1918.

[2] Idem, p. 167.

WASHINGTON.

The total production of gold in Washington from earliest mining to the end of 1917 is given by C. N. Gerry, of the United States Geological Survey, as $27,448,700, and the total production of silver as 7,053,400 fine ounces.[1]

Gold.—The mine production of gold in Washington in 1917 was $492,324, against $577,655 in 1916. Of the production in 1917 more than 70 per cent was derived from ores shipped directly to smelters, 28 per cent came from ores treated by amalgamation or cyanidation, and less than 1 per cent came from placers. Siliceous ores supplied about 97 per cent of all gold recovered and copper ores about 1 per cent. Ferry County alone produced $332,071 in 1917, against $399,376 in 1916. Nearly all the yield from Ferry County was, as usual, from the Republic district.

Silver.—The mine production of silver in Washington decreased from 335,121 ounces in 1916 to 282,320 ounces in 1917, of which Ferry County produced 98,080 ounces, mainly from siliceous ores, and Stevens County 161,013 ounces, mainly from copper ores.

WYOMING.

The total production of gold in Wyoming from 1867 to the end of 1917 is given by Charles W. Henderson as $1,235,100 and the output of silver for the same period as 68,575 ounces.[2]

The mine production of gold in Wyoming in 1917 was $3,762, against $20,566 in 1916, and that of silver 3,415 ounces in 1917, against 5,524 ounces in 1916. The Copper Mountain district, in Fremont County, produced most of the gold mainly from copper ores shipped to smelters. Copper ores shipped from mines in Albany, Lincoln, and Platte counties contained nearly all the remainder of the gold and silver reported in 1917.

PHILIPPINE ISLANDS.

The output of gold in the Philippine Islands from 1907 to 1917, inclusive, has been $7,759,522. The mine production of gold for 1917 was $1,408,161, against $1,514,200 in 1916, $1,320,900 in 1915, $1,371,514 in 1914, $868,362 in 1913, and $570,212 in 1912. The mine production of silver in the Philippine Islands in 1917 was 4,019 ounces and was recovered entirely from gold bullion refined.

NUMBER OF PRODUCING MINES.

The following table indicates the number of mines producing gold and silver in 1917 divided into placers and deep or lode mines. The placers are those in which the gold and the silver in natural alloy with the gold and, in a few placers, found also with platinum are recovered from gravels and sands, whether by hand washing, sluicing, hydraulicking, drifting (in frozen ground or ancient buried river channels), or by dredging. The deep mines are those producing gold and silver (from ores as distinguished from gravels) mainly from underground workings, including those whose ores are valuable chiefly for copper, lead, or zinc, but which contribute precious metals as by-products. In addition to producing mines here enumerated, many properties were being prospected and developed (though prospecting and development were less active than usual) without making any output in 1917, and many other mining claims were being held by assessment work only.

---

[1] U. S. Geol. Survey Mineral Resources, 1917, pt. 1, p. 493, 1918.
[2] Idem, p. 161.

The enumeration of placer mines is less satisfactory than that of deep mines, because some of the operations are only temporary and individually small and because the production is frequently by transitory miners not regularly working placer ground. The unit, so far as possible is, however, as for deep mines, not the operator, but the mining claim or group of claims.

Number of producing gold and silver mines in 1917.[a]

State or Territory.	Number of mines.			State or Territory.	Number of mines.		
	Placer.	Deep.	Total.		Placer.	Deep.	Total.
Alabama		1	1	North Carolina	14	7	21
Alaska	810	40	850	Oregon	53	23	76
Arizona	32	452	484	South Carolina	2	1	3
California	249	241	490	South Dakota	7	23	30
Colorado	33	715	748	Tennessee[c]		7	7
Georgia	13	6	19	Texas		9	9
Idaho	112	247	359	Utah	3	331	334
Illinois[b]		2	2	Vermont and New Hampshire		3	3
Maryland and Pennsylvania		3	3	Virginia[c]		5	5
Michigan[b]		10	10	Washington	17	119	136
Missouri		4	4	Wyoming	1	16	17
Montana	99	518	617				
Nevada	91	852	943		1,552	3,811	5,363
New Mexico	16	176	192				

[a] Philippine Islands and Porto Rico not included.
[b] Number of mines contributing to production of silver.
[c] Number of mines contributing to production of gold and silver.

The table shows the number and distribution of mines producing gold and silver in the United States and Alaska. With the exception of (1) some of the Michigan copper mines, (2) all zinc mines in the Eastern and Central States and a few in the far West, and (3) all lead mines of the Central States (except a few in Illinois and southeastern Missouri), practically all mines producing copper, lead, and zinc in the United States and Alaska produce gold and silver also. The table, therefore, with these exceptions, is a table of mines producing these five metals. It also includes certain mines producing oxidized manganese iron fluxing ores of Colorado, Utah, and elsewhere, whose ores contain small quantities of precious metals, especially silver, and are smelted as flux.

Number of mines producing gold and silver, 1906–1917.

Year.	Placer.	Deep.	Total.	Year.	Placer.	Deep.	Total.
1906	2,316	2,114	4,430	1913	1,774	3,502	5,276
1907	2,586	2,604	5,190	1914	1,815	3,158	4,973
1908	2,599	2,864	5,463	1915	1,720	3,597	5,317
1909	2,187	3,183	5,370	1916	1,530	3,765	5,295
1910	2,026	3,299	5,325	1917	1,552	3,811	5,363
1911	2,146	3,553	5,699				
1912	2,044	3,567	5,611	Average	2,025	3,251	5,276

Comparison of the figures for 1917 shows a net total increase of 68 producing mines, following decrease in 1912, 1913, 1914, and 1916, and an increase of 344 mines in 1915. The total number of properties operated in 1917 was 87 in excess of the average for the last 12 years. The number of placer properties worked in 1917 showed an increase of 22, but the total was nearly 800 less than the number operated in 1906. This is a natural result due to the exhaustion of the rich gravels and to the acquisition of large areas of placer ground by dredge mining companies. The number of deep mines operated increased from 3,765 in 1916 to 3,811 in 1917, or 560 more than the average for 12 years. High prices for copper, lead, and zinc in 1917 resulted in more deep mines being operated than in any year for which data are available by the Survey.

In total number of operating mines Nevada ranked first with 943, followed in order by Alaska with 850, Colorado with 748, Montana with 617, California with 490, Arizona with 484, and Idaho with 359. In number of placers Alaska led with 810, followed by California with 249, and Idaho with 112; and in deep mines Nevada led with 852, followed by Colorado with 715, Montana with 518, Arizona with 452, Utah with 331, Idaho with 247, and California with 241.

ORE PRODUCTION, CLASSIFICATION, AND AVERAGE VALUE.

The best index of deep mining is, of course, the quantity, metallic content, and value of ore mined, rather than the number of mines or of operators. In the next following table are given the production of ore by classes of ore and by States and Territories from mines producing gold and silver and the average extraction value of precious metals per ton.

The classification adopted is necessarily arbitrary in part. An ore is generally understood to be worked at a profit for one or more metals. The complex nature of western ores, especially, and the gradations from one well-recognized class to another render essential some fixed measures for the terminology used. The dry or siliceous ores comprise gold and silver ores proper, as well as fluxing ores carrying considerable quantities of iron and manganese oxides and very small quantities of gold and silver, and precious metal bearing ores carrying copper, lead, or zinc in quantities too low to classify them as copper, lead, zinc, or mixed ores. The distinction beween gold and silver ores is not here made. The total number of silver mines and the total production of true silver ores are both very small. The copper ores include those containing 2.5 per cent or more of copper, or less than this percentage in the cases of the great disseminated copper deposits of the West and of the Lake Superior ores; in general, the lead ores are those containing 4.5 per cent or more of lead, and the zinc ores are those containing 25 per cent or more of zinc, both irrespective of their precious-metal content; but ores of lower grades in lead and especially in zinc are treated profitably in some places, and of course they are then classified as lead or zinc ores, as the case may be. The mixed ores are combinations of those enumerated.

Ore produced and average extraction value of gold and silver per ton in 1917.[a]

State or Territory.	Dry or siliceous ores.		Copper ores.		Lead ores.	
	Quantity (short tons).	Average value.	Quantity (short tons).	Average value.	Quantity (short tons).	Average value.
Alabama and Georgia	19,320	$0.33	39,290	....	....	....
Alaska	3,414,664	1.37	659,951	$1.70	....	....
Arizona	317,716	10.79	15,245,297	.41	82,285	$6.98
California	2,018,003	5.13	892,579	1.57	92,533	7.54
Colorado	1,996,590	9.13	33,233	9.17	103,081	13.18
Idaho	69,650	8.36	103,224	2.65	1,448,285	4.62
Maryland and Virginia [b]	....	....	15,490	.06	....	....
Michigan [b]	....	....	3,240,000	.18	....	....
Montana	444,222	6.76	4,844,537	1.63	28,923	14.42
Nevada	1,413,929	9.86	4,945,482	.26	66,614	8.10
New Hampshire and Vermont	....	....	5,851	.08	....	....
New Mexico	221,662	7.27	4,188,027	.11	17,426	3.75
North Carolina and South Carolina	1,303	4.30	882	5.11	32	5.03
Oregon	99,397	7.90	43,041	1.76	....	....
South Dakota	1,867,859	4.02	82	1.52	369	12.03
Tennessee	....	....	589,004	.15	....	....
Texas	51,966	9.40	298	4.48	51	15.94
Utah	164,057	14.33	14,121,671	.27	638,071	10.55
Washington	65,639	8.83	75,006	1.78	16,407	.28
Wyoming	49	39.49	6,286	.73	....	....
Total, 1917	12,166,026	5.56	49,049,181	.49	2,494,077	6.88
Percentage of tonnage	18.11	....	73.02	....	3.71	....
Total, 1916	12,921,268	5.73	47,478,127	.51	2,373,579	5.95
Percentage of tonnage	19.46	....	71.52	....	3.58	....

	Zinc ores.		Copper-lead and copper-lead-zinc ores.		Lead-zinc ores.		Total (short tons).
	Quantity (short tons).	Average value.	Quantity (short tons).	Average value.	Quantity (short tons).	Average value.	
Alabama and Georgia	....	....	....	....	....	....	58,610
Alaska	....	....	42	$133.33	....	....	4,074,657
Arizona	62,839	$2.86	12,985	6.42	49,071	$4.18	15,770,193
California	135	.17	....	....	....	....	3,003,250
Colorado	140,445	.19	2,976	45.47	412,371	2.25	2,688,706
Idaho	19,269	1.27	4	165.41	1,118,075	2.68	2,758,507
Maryland and Virginia [b]	....	....	....	....	9,317	.54	24,807
Michigan [b]	....	....	....	....	....	....	3,240,000
Montana	258,846	1.32	4,356	21.24	726,280	2.89	6,307,164
Nevada	18,393	.13	1,158	20.34	27,943	5.40	6,473,519
New Hampshire and Vermont	....	....	....	....	3,000	.03	8,851
New Mexico	135,129	.02	3,684	7.12	10,899	.82	4,576,827
North Carolina	....	....	....	....	....	....	2,167
Oregon	....	....	....	....	....	....	142,438
South Dakota	....	....	....	....	....	....	1,868,310
Tennessee [d]	....	....	....	....	....	....	589,004
Texas	40	....	27	2.34	....	....	52,382
Utah	6,535	....	6,443	12.23	421,704	8.57	15,858,481
Washington	114	....	....	....	14,953	.08	172,119
Wyoming	....	....	....	....	....	....	6,335
Total, 1917	641,755	.90	31,675	14.58	2,793,613	2.82	67,176,327
Percentage of tonnage	.95	....	.05	....	4.16	....	....
Total, 1916	833,345	1.21	79,992	5.54	2,702,091	2.31	66,388,402
Percentage of tonnage	1.25	....	.12	....	4.07	....	....

[a] Illinois, Missouri, the Philippine Islands, and Porto Rico not included; quantity of crude ore containing precious metals not known.
[b] Includes only copper ore yielding precious metals.
[c] Lead and zinc ores yielded no precious metals.

The total quantity of ore sold or treated from which gold or silver was produced increased from 66,388,402 short tons in 1916, the largest production recorded, to 67,176,327 short tons in 1917. The total of such ores has increased more than 16,600,000 tons in two years. In 1917 the quantity of copper ores sold or treated increased more than 1,500,000 tons, and lead-zinc ore more than 91,000 tons; dry or siliceous ores decreased more than 750,000 tons; zinc ores, nearly 200,000 tons; copper-lead ores, 48,000 tons. Arizona, Utah, Nevada, and Montana led in quantity of ore, owing to the largely increased output from copper mines, the ore from Arizona and Utah being mainly from low-grade disseminated ores and that from Montana mainly from the Butte vein deposits. Nevada ore was mainly from Ely copper ores, but also from siliceous ores from Goldfield, Tonopah, and other districts. Alaska, New Mexico, California, Idaho, and Colorado come next, with an output mainly of dry or siliceous ores from many districts in Alaska, California, and Colorado, and of copper ores from the low-grade ore bodies in New Mexico.

The large production of lead and lead-zinc ores in Idaho ranked that State before South Dakota, which produced ores that were mainly dry or siliceous in character.

The average extraction values in gold and silver were comparatively high for the siliceous ores of Colorado, New Mexico, Nevada, Montana, Oregon, Utah, Idaho, Texas, and Washington, and low for the larger ore bodies of California, South Dakota, and Alaska. Some of the States produced comparatively small quantities of copper ore carrying high extraction values in gold and silver, but the copper ores of the important copper-producing States showed low extraction values. The average recovery in gold and silver from the copper ores of Arizona was $0.41 a ton, that of Tennessee $0.15 a ton, that of Montana $1.63 a ton, that of Nevada $0.26, that of New Mexico $0.11, that of Utah $0.27, that of California $1.57, and that of Michigan $0.18. The lead ores of Utah showed an average recovery in gold and silver of $10.55 a ton, and the lead ores of Idaho only $4.62 a ton. Idaho produced the largest quantity of gold and silver bearing lead ores, and also of lead-zinc ores. Utah yielded the next largest quantity of lead ore, but the gold and silver content of such ore was less than that of Montana ore of similar character. About 18.1 per cent of the output of ore considered as producing gold and silver was dry or siliceous ore, against 19.5 per cent in 1916; 73 per cent was copper ore, against 71.5 per cent in 1916; 3.71 per cent was lead ore; 4.16 per cent was lead-zinc ore; 0.95 per cent was zinc ore, and 0.05 per cent was copper-lead ore. The average precious-metal extraction value per ton of siliceous ores of the United States decreased from $5.73 to $5.56, that of zinc ores from $1.21 to $0.90, and that of copper-lead ores increased from $5.54 to $14.58. The average gold and silver value of copper ores per ton was 51 cents in 1916 and 49 cents in 1917, and that of lead-zinc ores increased from $2.31 to $2.82.

DISTRIBUTION OF MINE PRODUCTION OF GOLD IN 1917, BY SOURCES.

As shown by the following table, the great bulk of the domestic output of gold is obtained from dry or siliceous ore—normally gold quartz and gold-silver quartzose ores—and from placers, more than 88 per cent of the total production of gold coming from these sources alone. The total contribution of gold derived from the great copper, lead, and zinc mines of the country is therefore relatively small, notwithstanding their recent enormous development and production of ore.

It is interesting to note, however, that the placer mines and dry or siliceous ores yielded 2 per cent less of the total gold than they did in 1915 and that the output of gold from placer mines, which had advanced from nearly 24 per cent of the total gold in 1910 to more than 25 per cent in 1914 and had declined to less than 23 per cent in 1915, increased to 25 per cent in 1916, and 26.3 per cent in 1917. This increase in percentage was due, however, not so much to increased output from placers as to smaller production from deep mines. The contribution of gold from dry or siliceous ores, which had gradually declined from about 69 per cent in 1910 to about 66 per cent in 1914 and had increased to nearly 68 per cent in 1915, decreased more than 4 per cent in 1916 and was only 62 per cent in 1917. The yield of gold from copper ores, which had increased from 6 per cent in 1914 to 7 per cent in 1915 and to 9 per cent in 1916, decreased to less than 9 per cent in 1917.

Mine production of gold in 1917, in fine ounces.[a]

State or Territory.	Placers.	Dry or siliceous ores.	Copper ores.	Lead ores.	Zinc ores.	Copper-lead and copper-lead-zinc ores.	Lead-zinc ores.	Total.
Alabama and Georgia	135.99	306.69						442.68
Alaska	474,558.75	221,505.73	12,830.16			154.81		709,049.45
Arizona	832.73	131,997.57	98,530.97	5,739.02	4,078.35	2,352.86	1,642.33	245,173.83
California	438,956.20	495,581.36	32,408.98	4,786.46				971,733.00
Colorado	31,977.24	692,605.90	7,455.00	19,220.70	522.63	1,239.89	7,879.86	760,901.22
Idaho	6,541.80	24,929.28	3,960.99	2,567.41			933.16	38,932.64
Maryland, New Hampshire, and Vermont			6.62					6.62
Montana	22,594.17	107,172.83	27,561.56	4,688.65	1,475.24	281.45	6,373.21	170,147.11
Nevada	14,153.75	268,671.85	49,419.80	3,939.81	8.22	263.74	207.09	336,664.26
New Mexico	589.16	39,496.75	10,876.11	367.20	.43	88.74	60.25	51,478.64
North Carolina	192.48	222.68	168.86	5.53				589.55
Oregon	35,186.33	34,554.41	2,424.99					72,165.73
South Carolina	7.94	44.45						52.39
South Dakota	44.70	356,168.17	.85	1.05				356,244.77
Tennessee			257.65					257.65
Texas			.06	1.00				1.06
Utah	5.42	20,394.61	94,844.85	27,115.49		92.25	19,853.05	162,305.67
Virginia							64.97	64.97
Washington	283.86	23,240.61	281.93	1.55			8.22	23,816.17
Wyoming	1.64	92.30	88.04					181.98
Total, 1917	1,026,062.16	2,416,985.19	341,117.42	68,463.87	6,084.87	4,473.74	37,022.14	3,900,209.39
Value	$21,210,587	$49,963,518	$7,051,523	$1,415,274	$125,786	$92,480	$765,316	$80,624,484
Percentage of total	26.31	61.97	8.75	1.75	0.16	0.11	0.95	
Total, 1916	1,106,900.45	2,796,041.63	400,849.30	71,921.71	8,302.30	4,452.36	28,538.82	4,417,006.57
Value	$22,881,663	$57,799,310	$8,286,290	$1,486,754	$171,624	$92,030	$589,950	$91,307,630
Percentage of total	25.06	63.30	9.07	1.63	.19	.10	.65	

[a] Philippine Islands and Porto Rico not included.

PLACERS.

GENERAL.

The total value of the production of gold from placers was $21,210,587 in 1917, against $22,881,663 in 1916. The placer production increased in California by 24,109 ounces in 1917, but decreased in Alaska, Oregon, Colorado, Nevada, Idaho, and Montana.

The placer production is derived chiefly from dredging, from drift mining (which is of decreasing importance in Alaska in frozen ground at no great depth, but of continued importance in California in ancient buried river channels, often at considerable depth), and from hydraulic and sluicing placers. In California, especially, hydraulic mining was of much importance in the past and had become a special branch of the industry in itself, but restrictive laws relative to the débris and to disturbance of navigable streams have in recent years greatly confined mining activity of this kind. Finally, there is a small annual output of gold from dry placers in the Southwest and also a production of gold and platinum from ocean-beach mining in California and Oregon.

Some interesting notes on beach mining in California and Oregon and on dry placers in California, by Charles G. Yale, and on dry placers in Arizona, Nevada, and New Mexico, by V. C. Heikes, were published in the Survey report on gold and silver for 1912, copies of which can still be had on application to the Director, United States Geological Survey, Washington, D. C.

DREDGING.

The production of gold by dredging in the United States and Alaska from the commercial beginning of the industry in 1896 to the end of 1917 has amounted in value according to best available data to $132,653,700, of which $95,193,985 came from California, $17,609,894 from Alaska, $8,509,188 from Montana, $4,750,919 from Colorado, and $3,691,502 from Idaho. Oregon produced more gold from dredging in 1916 and 1917 than Montana or Idaho and nearly as much as Colorado, and the total production from dredges in Oregon has been more than $2,500,000.

Brief details of dredging operations have been given in Mineral Resources in the mines reports on gold, silver, copper, lead, and zinc of the Western States and also in earlier reports of the Director of the Mint. A brief history of gold dredging in the United States was given in the gold and silver (general) report for the year 1914, and the production of gold obtained by dredging in the United States and Alaska from 1896 to the end of 1914 and the number of dredges operated was given by States for each year. Further information is to be found in reports of geological surveys or mining officials of different States. A comprehensive and very useful report is contained in Bulletin 57 of the California State Mining Bureau, "Gold dredging in California," by W. B. Winston and Charles Janin. Other valuable treatises are "Dredging for gold in California," by D'Arcy Weatherbe, published by the Mining and Scientific Press; and "The history and development of gold dredging in Montana," by Hennen Jennings, with a chapter on placer mining methods and costs, by Charles Janin, published as Bulletin 121 of the Bureau of Mines. The most recent valuable contribution is "Gold dredging in the United States," by Charles Janin, published as Bulletin 127 of the Bureau of Mines.

The gold recovered in the United States and Alaska by 109 gold dredges in 1917 was $12,550,425, against $12,786,614 by 113 dredges in 1916. Of the output in 1917, California produced $8,313,527 from 55 dredges, Alaska $2,500,000 from 36 dredges, Montana

$409,455 from 3 dredges, Colorado $647,270 from 6 dredges, and Idaho $59,446 from 4 dredges. Four dredges operating in Oregon produced $618,922.

Gold produced in the United States by dredges, 1896–1917.

Year.	Dredges.	California.	Alaska.	All other States.[a]	Total.
1896	2	$2,000		$42,000	$44,000
1897	6	5,000		113,556	118,556
1898	8	18,887		168,813	187,700
1899	18	206,302		227,876	434,178
1900	27	200,929		319,108	520,037
1901	34	471,762		268,251	740,013
1902	48	867,665		501,857	1,369,522
1903	45	1,475,749	$20,000	420,315	1,916,064
1904	61	2,187,038	25,000	511,679	2,723,717
1905	68	3,276,141	40,000	371,235	3,687,376
1906	76	5,098,359	120,000	503,035	5,721,394
1907	79	5,065,437	250,000	340,265	5,655,702
1908	88	6,536,189	170,901	646,481	7,353,571
1909	96	7,382,950	424,993	975,656	8,783,599
1910	115	7,550,254	800,000	942,786	9,293,040
1911	119	7,666,461	1,500,000	1,159,908	10,326,369
1912	124	7,429,955	2,200,000	1,588,956	11,218,911
1913	116	8,090,294	2,200,000	1,936,642	12,226,936
1914	120	7,783,394	2,350,000	2,379,389	12,512,783
1915	114	7,796,465	2,330,000	2,356,660	12,483,125
1916	113	7,769,227	2,679,000	2,338,487	12,786,614
1917	109	8,313,527	2,500,000	1,736,898	12,550,425
		95,193,985	17,609,894	19,849,853	132,653,732

[a] Other States that have produced gold by dredges are Colorado, which yielded, 1901–1917, $4,750,919 Idaho, 1897–1917, $3,691,502; Montana, 1896–1917, $8,509,188; and Oregon, New Mexico, Nevada, South Dakota, Wyoming, Alabama, Georgia, and North Carolina, a combined yield, 1902–1917, of $2,898,244.

DRY AND SILICEOUS ORES.

In 1917 dry and siliceous ores, including true gold, gold-silver, and silver ores, and precious metal ores not classed primarily as copper, lead, zinc, or mixed ores, produced $49,963,518 in gold, against $57,799,310 in 1916. The largest producers from this class of ore are in order of rank: Colorado, California, South Dakota, Nevada, and Alaska.

The siliceous ores are in part free-milling (amalgamating), as in Alaska, California, and Oregon; both amalgamating and concentrating, as in many States; simply concentrating ores, as in parts of Colorado and Arizona; all-sliming and cyaniding ores; and finally smelting ores. Tailings both from old dumps and from present millings are largely reworked by concentration and subsequent cyanidation.

The loss in tailings from gold mills is being constantly cut down, and the most serious loss remains in tailings from concentrating plants. The chlorination process is of decreasing relative importance, having been used in only a few plants in California in 1917. Smelting is mainly of concentrates and of siliceous and pyritic ores, which are also valuable as fluxes. Exact figures of relative output by methods will appear in detail by States in another table.

As most of the production of gold in the United States is derived from placer gravels and dry or siliceous ores, including true gold, gold-silver, and silver ores, the following table for certain States, prepared by V. C. Heikes, of the United States Geological Survey, is of special interest. The table shows the quantity of each class of ore treated and the average content in gold per ton for the period

1913 to 1917, inclusive, for Arizona, Idaho, Montana, Nevada, Utah, and Washington. None of the States have a large yield of gold from gold-silver ores, and Nevada, with a yield much less in 1917 than in 1913, was the only State that produced a large quantity of gold from silver ores. Arizona shows an increase both in quantity of gold ore treated and of gold recovered, though the average content per ton in 1917 was slightly less than in 1913. In Idaho the quantity of gold ore treated in 1917 was nearly double that in 1913, but the average recovery decreased from 0.410 ounce per ton in 1913 to 0.365 ounce per ton in 1917. In Montana nearly 180,000 tons more of gold ore was treated in 1917 than in 1913 and the average yield per ton of ore decreased from 0.369 ounce in 1913 to 0.252 ounce in 1917. In Nevada the quantity of gold ore treated in 1917 was 183,000 tons less than in 1913 and the average recovery of gold per ton decreased from 0.438 ounce to 0.292 ounce.

The yield of gold from gold ores in Utah has been comparatively small in recent years and although there was an increased quantity of gold recovered from such ores in 1917 compared with 1916, the yield was less than $100,000, which is less than one-half that for the year 1913. The quantity of gold ores treated in Washington in 1917 was larger than in 1913, but the average recovery per ton declined from 0.570 ounce in 1913 to 0.356 ounce in 1917.

Gold produced in six Western States during 1913–1917—total quantity of ore mined and gold produced, compared with quantity and content of gold ore, gold-silver ore, silver ore, and ounces of placer gold, and with number of producers in each class.

Year.	Total number of producers.	Total quantity of ore mined.	Total gold.[a]	Gold ore.			
				Number of producers.	Quantity.	Gold.	Average content.
Arizona:		*Short tons.*	*Fine ounces.*		*Short tons.*	*Fine ounces.*	
1913	438	7,931,862	194,656.69	116	210,228	120,351.91	0.572
1914	395	8,009,927	202,166.62	121	263,895	136,558.47	.517
1915	517	9,612,559	201,531.46	139	182,251	92,771.19	.509
1916	527	17,033,810	192,801.41	105	164,918	63,562.20	.385
1917	484	15,770,193	245,173.83	86	236,585	128,801.16	.544
Idaho:							
1913	384	2,451,592	65,043.04	76	36,729	15,074.89	.410
1914	384	2,235,349	55,743.24	84	37,098	13,407.04	.361
1915	412	2,408,846	57,069.49	102	51,786	21,681.77	.419
1916	418	2,718,045	53,977.30	75	69,443	25,068.28	.361
1917	359	2,758,507	38,932.64	70	67,784	24,721.63	.365
Montana:							
1913	558	5,960,118	168,994.77	182	229,520	84,748.32	.369
1914	505	5,128,956	199,203.94	183	315,804	116,964.96	.370
1915	643	6,129,924	242,077.93	225	466,818	150,169.29	.322
1916	513	7,860,425	220,130.15	150	498,082	131,175.61	.263
1917	617	6,307,164	170,147.11	137	411,118	103,835.48	.252
Nevada:							
1913	786	5,367,211	570,589.41	323	772,749	338,770.66	.438
1914	731	4,522,022	555,402.47	310	837,699	334,137.48	.399
1915	799	5,118,620	551,683.01	206	959,304	333,907.39	.348
1916	779	5,941,165	428,904.21	308	817,100	232,699.56	.285
1917	943	6,473,519	336,664.26	287	589,228	171,815.15	.292
Utah:							
1913	217	10,202,566	172,467.95	5	68,408	11,974.24	.175
1914	211	8,544,014	157,961.16	5	1,987	856.32	.430
1915	234	10,451,445	174,590.65	7	13,883	3,226.24	.232
1916	318	13,920,643	172,938.06	10	1,308	663.82	.508
1917	334	15,358,481	162,306.67	6	14,728	4,678.60	.318
Washington:							
1913	57	15,685	33,682.30	26	56,008	31,943.93	.570
1914	67	95,947	26,953.24	22	73,618	26,184.86	.356
1915	104	86,677	18,934.90	46	41,412	18,223.36	.440
1916	113	164,998	27,944.06	38	70,048	26,932.84	.384
1917	136	172,119	23,816.17	23	65,058	23,166.31	.356

Gold produced in six Western States during 1913–1917—Continued.

Year.	Gold-silver ore.		Silver ore.		Placers.	
	Quantity.	Gold.	Quantity.	Gold.	Number of producers.	Gold.
	Short tons.	*Fine ounces.*	*Short tons.*	*Fine ounces.*		*Fine ounces.*
Arizona:						
1913	1,261	406.82	32,216	1,858.40	36	1,484.67
1914	58	46.78	128,759	8,230.65	57	1,458.02
1915	14,349	2,338.97	144,198	9,189.84	49	1,705.12
1916	1,470	994.00	169,916	8,858.47	23	690.84
1917	1	3.62	80,817	3,192.79	32	832.73
Idaho:						
1913	23,390	7,238.56	206	27.82	235	33,574.81
1914	44	92.42	1,100	176.56	208	33,884.46
1915	119	90.81	397	162.87	186	28,294.05
1916	447	227.19	1,793	201.15	162	21,724.87
1917	....	....	1,866	207.64	112	6,541.80
Montana:						
1913	13,586	3,763.07	41,382	4,237.81	152	38,748.47
1914	427	451.46	25,854	4,182.65	147	45,579.75
1915	1,025	125.64	25,657	4,760.58	161	45,219.87
1916	999	176.45	24,761	4,075.20	120	34,982.82
1917	7	2.20	33,097	3,335.15	99	22,594.17
Nevada:						
1913	72,909	27,115.32	697,775	144,961.52	64	14,775.75
1914	6,878	3,929.80	676,573	146,181.17	111	18,250.05
1915	16,558	5,372.05	721,753	127,079.12	103	19,123.55
1916	13,330	2,681.38	721,211	116,039.39	65	17,139.89
1917	17,614	3,099.45	807,087	93,757.16	91	14,153.75
Utah:						
1913	82,165	16,425.10	73,294	4,172.90[a]	7	92.88
1914	77,653	11,901.80	69,379	5,508.11	7	59.55
1915	11,135	1,534.16	36,958	4,488.27	6	46.34
1916	4,337	1,130.41	83,718	7,328.18	8	60.47
1917	25,318	4,864.68	124,011	10,851.33	3	5.42
Washington:						
1913	4	58.00	120	23.00	12	200.00
1914	....	....	274	269.00	17	278.45
1915	....	....	748	54.36	31	346.00
1916	....	....	428	46.19	23	400.40
1917	48	30.89	533	43.41	17	283.86

[a] Includes placer production given in last column.

Nearly all the siliceous ore in three of the largest gold-producing States—Alaska, California, and South Dakota—yields only small values in silver and is classed as gold ore. The siliceous ores from Colorado include some silver and gold-silver ores, but the great bulk of the siliceous ore is purely gold ore. The quantity of siliceous ore treated each year in these States and the average recovery in gold per ton is as follows:

Siliceous ore treated and gold recovered per ton of ore treated in 1913–1917.

Year.	Alaska.		California.		South Dakota.		Colorado.	
	Ore treated.	Recovery per ton.	Ore treated.	Recovery per ton.	Ore treated.	Recovery per ton.	Ore treated.	Recovery per ton.
	Short tons.	*Ounces.*	*Short tons.*	*Ounces.*	*Short tons.*	*Ounces.*	*Short tons.*	*Ounces.*
1913	1,614,506	0.144	2,031,429	0.267	1,899,139	0.187	2,161,458	0.378
1914	1,738,127	.135	2,050,797	.264	2,019,255	.175	2,157,762	.414
1915	3,020,607	.097	2,368,352	.272	1,889,970	.189	2,183,431	.464
1916	3,548,798	.081	2,192,078	.262	1,870,721	.193	2,057,452	.412
1917	3,414,664	.065	2,018,003	.246	1,867,859	.191	1,996,590	.347

COPPER ORES.

The production of gold as a by-product of the smelting of copper ores sold or treated in 1917 was $7,051,523, against $8,286,290 in 1916, a decrease from 9.07 per cent of the total gold yield in 1916 to 8.75 per cent in 1917. The largest production was in Arizona, followed by Utah, Nevada, California, and Montana, in the order given. The largest decrease was in Montana and California, caused by a smaller output of copper in those States. It is probable that the increase in the production of copper in Montana and Arizona in 1918 will result in a recovery of gold from copper ores equal to the output from that source in 1916.

LEAD ORES.

The production of gold in lead ores sold or treated in 1917, chiefly from Utah and Colorado, was $1,415,274, against $1,486,754 in 1916, or 1.75 per cent of the total domestic output of gold in 1917.

LEAD-ZINC, ZINC, AND OTHER ORES.

The production of gold from lead-zinc ores was $765,316 in 1917, against $589,950 in 1916; from zinc ores $125,786 in 1917, against $171,624 in 1916; and from copper-lead and copper-lead-zinc ores $92,480 in 1917, against $92,039 in 1916.

DISTRIBUTION OF MINE PRODUCTION OF SILVER IN 1917, BY SOURCES.

The mine production of silver from the three most important sources of silver—dry or siliceous ores, copper ores, and lead ores—was 86.18 per cent of the total output in 1917. The output from dry and siliceous ores decreased 0.77 per cent in 1917, following a decrease of 4.35 per cent in 1916; that from lead ores increased 2.65 per cent; that from lead-zinc ores increased about 1.35 per cent; and that from copper ores decreased 2.37 per cent. The combined output from placers, zinc ores, copper-lead ores, and copper-lead-zinc ores was about 1.6 per cent of the total production of silver.

Mine production of silver in 1917, in fine ounces.[a]

State or territory.	Placers.	Dry or siliceous ores.	Copper ores.	Lead ores.	Zinc ores.	Copper-lead and copper-lead-zinc ores.	Lead-zinc ores.	Total.
Alabama and Georgia	9	48	......	......	......	......	......	57
Alaska	64,410	131,631	1,040,185	......	......	2,924	......	1,239,150
Arizona	227	848,500	5,214,411	553,544	116,179	61,019	190,033	6,983,913
California	27,257	139,492	882,480	725,174	28	......	(b)	1,775,431
Colorado	8,302	4,867,628	182,791	1,167,167	19,525	133,128	925,812	7,304,353
Idaho	1,194	81,514	232,840	8,063,768	29,684	803	3,619,535	12,029,338
Illinois [c]	......	......	......	7,186	......	......	......	7,186
Maryland, New Hampshire and Vermont	......	......	1,589	......	......	......	120	1,709
Michigan	......	......	688,551	......	......	......	......	688,551
Missouri	......	......	20	61,566	......	......	......	61,586
Montana	3,551	954,477	8,911,389	388,435	378,239	105,227	2,386,824	13,128,142
Nevada	6,278	10,176,717	327,751	556,706	2,620	21,967	177,930	11,269,969
New Mexico	92	966,006	315,877	70,021	3,381	29,600	9,388	1,394,365
North Carolina	34	97	922	57	......	......	......	1,110
Oregon	7,160	87,121	31,375	......	......	......	......	125,656
South Carolina	......	3	......	......	......	......	......	3
South Dakota	4	182,023	130	4,608	......	......	......	186,765
Tennessee	......	......	99,053	......	......	......	......	99,053
Texas	......	593,128	1,621	962	......	78	......	595,789
Utah	......	2,340,537	2,225,119	7,490,650	......	93,296	1,329,531	13,479,133
Virginia	......	......	......	......	......	......	4,518	4,518
Washington	86	120,510	154,747	5,630	......	......	1,347	282,320
Wyoming	......	33	3,382	......	......	......	......	3,415
Total, 1917	118,604	21,489,465	20,314,233	19,096,474	549,656	448,042	8,645,038	70,661,512
Value	$97,730	$17,707,319	$16,738,928	$15,735,495	$452,916	$369,187	$7,123,511	$58,225,086
Percentage of total	0.17	30.41	28.75	27.02	0.78	0.64	12.23	100.00
Total, 1916	126,351	24,593,656	24,541,234	19,216,586	1,274,292	533,273	8,572,141	78,857,583
Value	$83,139	$16,182,625	$16,148,132	$12,644,514	$838,484	$350,894	$5,640,469	$51,888,257
Percentage of total	0.16	31.18	31.12	24.37	1.61	0.68	10.88	100

[a] Philippine Islands and Porto Rico not included. [b] Included with lead ores. [c] Fluorspar-lead ore.

PLACERS.

The output of silver from the refining of placer gold was 118,604 fine ounces in 1917, against 126,351 ounces in 1916. Seventy-eight per cent of the production was from Alaska and California.

DRY AND SILICEOUS ORES.

The mine production of silver from dry and siliceous ores in 1917 was 21,489,465 fine ounces, against 24,593,656 ounces in 1916. About 48 per cent of this was from Nevada (chiefly from Tonopah district) and 23 per cent was from Colorado (mainly from the Leadville, Upper San Miguel, and Sneffels districts). The quantity of silver from siliceous ores mined in Utah increased from 1,153,993 ounces in 1916 to 2,340,537 ounces in 1917. There were decreases in all the other States, especially in Nevada, where the production in 1917 was 2,575,194 ounces less than in 1916. New Mexico and Montana also each produced more than 900,000 ounces of silver from this source, and Arizona nearly 850,000 ounces. Ninety-nine per cent of the silver produced in Texas was from siliceous silver ores.

A large part of the silver from gold-silver siliceous ores is obtained with the gold by amalgamation and cyanidation in the mills, and the silver is recovered by refining the mill bullion. The remainder is produced by smelting the richer ores and refining the copper or lead bullion produced.

COPPER ORES.

The mine production of silver from domestic copper ores in 1917 was 20,314,233 fine ounces, against 24,541,234 ounces in 1916, a decrease of about 12 per cent. The decrease in production of silver from copper ores mined in Alaska was 167,000 ounces; Arizona, 130,000 ounces; Utah, 408,000 ounces; Montana, 2,300,000 ounces; and California, 1,000,000 ounces. None of the larger copper-producing States had any increase in silver recovered from copper ores.

The production of silver from copper ores is from the electrolytic refining of Lake and blister copper produced by smelting. The copper ores are mainly sulphides (except the Lake ores of Michigan, which are native metal in amygdaloid and conglomerate matrix), and a greater tonnage contains chalcocite than chalcopyrite or cupriferous pyrite. The great disseminated copper deposits of Utah, Arizona, and New Mexico are of increasing importance and the lode deposits of Butte, Mont., have long been famous. The silver tenor of the extensive disseminated deposits of the Santa Rita district, N. Mex., and of Ely, Nev., are notably low, but similar deposits elsewhere add large quantities of silver.

In Michigan 3,240,000 tons of copper ore yielded 688,551 ounces of silver, or slightly more than 0.2 ounce per ton.

In output of silver from copper ores Montana continued to lead with 8,911,389 ounces in 1917, against 11,226,034 ounces in 1916; Arizona followed with 5,214,411 ounces in 1917, against 5,347,893 ounces in 1916; Utah ranked third with 2,225,119 ounces in 1917, against 2,633,402 ounces in 1916; and California produced 882,480 ounces in 1917, against 1,969,783 ounces in 1916. The production of Montana is mainly from Butte, that of Arizona has been chiefly from Bisbee and Jerome, that of Utah from Tintic and Bingham, and that of California from Shasta and Calaveras counties. Of these districts Bisbee well represents the disseminated type; Bingham produces from both lode and disseminated deposits; and the remainder produce silver chiefly from copper ore mined from deep lodes.

LEAD ORES.

The mine production of silver from argentiferous lead ores in 1917 was 19,096,474 fine ounces, against 19,216,586 ounces in 1916. The output from Idaho decreased from 8,227,936 ounces in 1916 to 8,063,768 ounces in 1917, that of Utah decreased from 8,118,264 ounces to 7,490,650 ounces, and that of Colorado was about the same as in 1917. The yield in Idaho is mainly from the silver-lead ores of the Coeur d'Alene, that in Utah is chiefly from the Park City and Tintic districts, and that in Colorado from Aspen and Leadville. There was an increase in the production of silver from lead ores in California from 325,468 ounces in 1916 to 726,174 ounces in 1917. There was also a small increase in both Nevada and Arizona. Most of the output is from the desilverization of lead bullion from smelting of western ores and concentrates.

ZINC, LEAD-ZINC, AND MIXED ORES.

Argentiferous zinc ores produced 549,656 ounces of silver in 1917, against 1,274,292 ounces in 1916, mainly as refinery by-products from the smelting of zinc concentrates from Montana, Idaho, California, and Arizona.

Lead-zinc ores produced 8,645,038 fine ounces of silver in 1917, against 8,572,141 ounces in 1916, chiefly from concentrates from the Coeur d'Alene in Idaho, the Butte district in Montana, and the Park City region in Utah. The output from Idaho decreased from 3,718,529 ounces in 1916 to 3,619,535 ounces in 1917.

Copper-lead and copper-lead-zinc ores produced 448,042 ounces of silver in 1917, against 533,273 ounces in 1916. The output was mainly from Utah, Montana, Colorado, and Arizona.

SILVER PRODUCTION, BY SOURCES, 1905–1917.

Production of silver in the United States, by sources, as reported by mines, 1905–1917, in fine ounces.[a]

Year.	Placers.	Dry or siliceous ores.	Copper ores.	Lead ores.	Zinc ores.	Copper-lead and copper-lead-zinc ores.	Lead-zinc ores.	Total.
1905	112,826	17,187,889	15,762,947	16,070,203	939,252	5,416,723	782,656	56,272,496
1906	171,058	16,792,799	15,880,870	15,328.653	98,423	6,815.678	2,274,972	57,362,453
1907	126,808	19,038,042	13,955,436	17,318.811	93,419	489,825	1,474,725	52,497,066
1908	159,285	19,862,038	14,945,189	14,049,481	37,605	1,099,283	722,906	50,875,787
1909	152,040	19,826,890	18.300,705	17,027,737	313,948	549,923	1,141,434	57,312,677
1910	159,381	23,125,042	16,024,543	15,028,076	755,369	535,987	1,968,311	57,596,709
1911	170,084	25,205.749	16,759,638	15,596,638	630,573	285,006	2,460,152	61,107,840
1912	163.955	26,363.436	18,744,661	16,632,377	664,421	654,596	2,810,939	66,034,385
1913	123,739	28,010,875	18.250,253	18,629.246	86,432	752,563	5,334,120	71,187,228
1914	152,128	27,812,335	14,829,828	19,302,081	145,264	248,866	7,132,747	69,623,249
1915	154,968	25,709,505	18,781,365	19,828,533	1,136.220	234.047	6,509,092	72,353,730
1916	126,351	24,593.656	24,541,234	19,216,586	1,274,292	533,273	8,572,141	78,857,533
1917	118,604	21,489,465	20,314,233	19,096,474	549,656	448,042	8,645,038	70,661,512
	1,891,227	295,017,721	227,090,902	223,124,896	6,724,874	18,063,812	49,829,233	821,742,665

[a] Philippine Islands excluded.

This table shows that the production of silver as reported by the mines has increased from 50,875,787 fine ounces in 1908 to 70,661,512 ounces in 1917. The production from siliceous, copper, lead, zinc, and lead-zinc ores all show an increase. The recoveries from dry or siliceous ores reached its apex in 1913 when the yield from Tonopah mines was at its zenith, and the production in 1917 was about 6,500,000 ounces less than it was in 1913. The yield of silver from copper ores has increased from 13,955,436 ounces in 1907 to 20,314,233 ounces in 1917, or about 46 per cent. The total yield of silver from zinc ores has been comparatively small, though the output from that kind of ore increased from 37,605 ounces in 1908 to nearly 550,000 ounces in 1917. The combined production of silver from lead and lead-zinc ore increased from 14,772,387 ounces in 1908 to 27,788,727, or 88 per cent.

The production of silver from siliceous ores will probably continue to decrease in 1918 and that from copper ores and lead ores may equal that of 1916. It is not expected that the production of silver in the United States in 1918 will show any increase, but the gain from copper and lead ores may nearly equal the loss in the recoveries from siliceous ores and zinc and zinc-lead ores.

DISTRIBUTION OF PRODUCTION OF GOLD AND SILVER BY METHODS OF TREATMENT.

SUMMARY OF DISTRIBUTION.

In the following table is given a summary of the distribution of the production of gold and silver in the United States in 1917, showing (1) total crude ore, tailings, and slags sold or treated; (2) crude ore treated in gold and silver mills; (3) crude ore concentrated and resulting concentrates; (4) crude ore shipped to smelters; (5) old tailings and slags treated. The last four items include recoverable gold and silver content in fine ounces.

Distribution of gold and silver produced in 1917, by States.[a]

State or Territory.	Total quantity of ore, tailings, and slag treated or sold in 1917.	Ore to gold and silver mills.			Crude ore—			
		Quantity.	Gold in bullion.	Silver in bullion.	To concentrating mills.	Concentrates produced from all sources.		
					Quantity.	Quantity.	Gold.	Silver.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Short tons.*	*Short tons.*	*Fine ounces.*	*Fine ounces.*
Alaska	4,074,657	3,101,131	117,689	29,290	769,776	75,156	103,813	574,976
Arizona	15,770,193	243,769	120,636	254,353	10,943,997	783,832	26,241	1,271,890
California	3,003,250	1,809,017	376,089	83,142	422,169	74,409	97,211	111,561
Colorado	2,688,706	1,486,384	553,554	400,109	700,014	280,563	87,650	2,600,743
Idaho	2,758,507	67,677	22,721	20,877	2,375,891	419,182	4,010	8,044,469
Montana	6,307,164	327,748	66,908	235,068	5,086,706	1,793,899	32,675	10,053,994
Nevada	6,473,519	1,125,255	248,057	9,241,543	4,524,310	627,416	50,466	713,459
New Mexico	4,576,827	123,824	26,271	657,437	4,215,988	360,614	10,168	196,713
Oregon	142,438	93,433	32,719	57,269	41,276	7,755	2,256	53,790
South Dakota	1,868,310	1,867,583	355,578	181,051	....	....	....	....
Texas	52,382	51,966	....	593,128	....	....	....	....
Utah	15,358,481	190	141	26	13,718,660	813,287	73,674	2,469,804
Washington	172,119	10,986	6,734	461	73,673	6,076	61	122,556
Wyoming	6,335	20	15	6	....	....	....	....
Eastern or Appalachian States[b]	682,994	20,214	416	67	33,347	2,770	72	5,976
Total	63,935,882	10,329,197	1,927,528	11,753,827	42,905,807	5,244,959	488,297	26,219,931
Total, 1916	64,409,377	11,249,436	2,118,252	14,724,426	43,371,329	5,496,226	547,172	29,566,150

---

[a] Exclusive of small quantity of silver from copper ores in Michigan and Missouri and from lead ores in Illinois and Missouri, and of gold and silver from the Philippine Islands and Porto Rico.

[b] Copper, zinc, and zinc-lead ores containing no silver excluded.

Distribution of gold and silver produced in 1917, by States—Continued.

State or Territory.	Crude ore to smelters.			Old tailings and slag treated.		
	Quantity.	Gold.	Silver.	Quantity	Gold.	Silver.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Short tons.*	*Fine ounces.*	*Fine ounces.*
Alaska	203,750	12,989	570,474	....	....	....
Arizona	3,782,494	96,923	5,312,292	799,933	[a] 541	[a] 145,151
California	566,069	39,653	1,524,109	205,995	19,824	29,362
Colorado	502,308	87,720	4,295,199	....	....	....
Idaho	284,567	5,636	3,926,092	30,372	24	36,706
Montana	503,023	47,631	2,580,608	389,687	[b] 339	[b] 254,921
Nevada	658,447	23,105	1,238,946	165,507	883	69,743
New Mexico	237,015	14,451	540,123	....	....	....
Oregon	6,720	1,746	2,457	1,009	258	4,980
South Dakota	727	622	5,710	....	....	....
Texas	416	1	2,661	....	....	....
Utah	1,178,002	87,030	10,498,129	461,629	1,455	511,174
Washington	87,416	16,704	159,174	44	33	43
Wyoming	6,315	165	3,409	....	....	....
Eastern or Appalachian States	628,600	367	99,369	833	222	995
	8,645,869	434,743	30,758,752	2,055,009	23,579	1,053,075
Total, 1916	8,894,609	634,366	33,161,551	894,030	10,305	427,281

[a] Gold and silver from 22,709 tons of old tailings, cyanided included, under recoveries at gold and silver mills.

[b] Gold and silver from 9,862 tons of old tailings, cyanided included, under recoveries at gold and silver mills.

The first item consists of all classes of ores, tailings, and slag from which gold and silver were produced in 1917. The grand total is 63,935,882 short tons in 1917, against 64,409,377 tons in 1916. This takes no account of placer gravel but represents output of mines producing ore only. The greatest output was from Arizona, Utah, Montana, Nevada, and Alaska, all notable for large yield of copper ores.

In reference to the second item many gold and silver mills employ concentrating apparatus, and the concentrates obtained are combined in the table with those from straight concentrating mills under the heading "Concentrates produced." The gold and silver recovery under this item is mainly by amalgamation and cyanidation, as is shown in detail in the last table of this report. The total quantity of crude ore treated in gold and silver mills in 1917 was 10,329,197 short tons, against 11,249,436 tons in 1916. The greatest quantities milled were in Alaska, California, South Dakota, Colorado, and Nevada. The total recovery of gold from the mills was 1,927,528 fine ounces in 1917, against 2,118,252 ounces in 1916, and the production was, as usual, chiefly from Colorado, California, South Dakota, and Nevada, in the order named. The total silver recovery in mills was 11,753,827 fine ounces, against 14,724,426 ounces in 1916, and came very largely from Nevada (from Tonopah and Goldfield chiefly), but also in considerable part from New Mexico, Texas, Arizona, and Colorado.

Under the third item is given the quantity of ore treated by concentration only, including the large quantities of copper, lead, zinc, and mixed ores, whose concentrates are smelted primarily for these metals, the gold and silver being recovered in refining the copper and lead bullion and smelting the zinc residues. Examples are the copper ores of the disseminated deposits of Bingham, Utah, and of New Mexico and Nevada; the copper ores of Butte, Mont., and the lead and lead-zinc ores of Coeur d'Alene, Idaho, Butte, Mont., and Leadville, Colo. The quantity of concentrates produced and the recoverable gold and silver content, however, as already stated, represent not only the concentrates from these straight concentrating mills but also those from gold and silver mills, which form, however, a very small part of the total quantity of concentrates and are mainly derived from Alaska, California, and Colorado ores. These concentrates are mainly smelted but are also treated in gold and silver mills by the processes named.

The ore treated in straight concentration mills decreased from 43,371,329 short tons in 1916 to 42,905,807 tons in 1917, mainly because of less activity at copper mines in Montana and Arizona. Utah ranked first in quantity of ore concentrated, followed by Arizona, Montana, Nevada, New Mexico, and Idaho. These quantities, with the exception of those of Montana and Idaho, represent largely low-grade disseminated copper ores milled. The total quantity of gold and silver bearing concentrates from all classes of milling ore decreased from 5,496,226 short tons in 1916 to 5,244,959 tons in 1917. Montana mills produced the largest quantity of concentrates, or 34 per cent, followed by those of Utah, Arizona, Nevada, and Idaho. The total recoverable gold content of all concentrates was 488,297 ounces in 1917, against 547,172 ounces in 1916, and came mainly from Alaska, California, Colorado, Utah, and Nevada, in the order named. The total recoverable silver from concentrates produced was 26,219,931 fine ounces in 1917, against 29,566,150 ounces in 1916, and came chiefly from Montana, Idaho, Colorado, Utah, and Arizona. The large decrease was due to the decrease in the silver in concentrates derived from ores mined in Montana and Nevada.

The fourth item covers the quantity and the recoverable precious-metal content of crude ores shipped from the mines direct to the smelters, and in general includes the richer gold, silver, copper, lead, and mixed ores from which the gold and silver is eventually recovered by refining the copper or lead bullion that collects the precious metals in the smelting. The total quantity shipped of this class of ore decreased from 8,894,609 short tons in 1916 to 8,645,869 tons in 1917. The output was notably from Arizona, followed by Utah, Nevada, California, Eastern or Appalachian States, Montana, and Colorado, in the order named. The total yield of gold from crude ores smelted decreased from 634,366 fine ounces in 1916 to 434,743 ounces in 1917, and came chiefly from Arizona, Colorado, Utah, Montana, California, and Nevada, in the order given. The total recoverable silver output decreased from 33,161,551 fine ounces in 1916 to 30,758,752 ounces in 1917, and was notably from Utah, Arizona, Colorado, Idaho, Montana, California, and New Mexico.

Under the fifth item is given the quantity of old materials, principally tailings and slags, retreated, and their recoverable contents. These are partly smelted, often for their fluxing as well as their metal value; but considerable quantities of old tailings are now concentrated and cyanided, and impounding of mill tailings for future treatment as well as because of legal requirements has now become a general practice. The total quantity of all old material treated as shown in the table increased from 894,030 short tons in 1916 to 2,055,009 tons in 1917. The increase in quantity of old material treated was due mainly to the high prices of copper and lead. Most of the gold and silver derived from old tailings is included under recoveries by amalgamation and cyanidation at gold and silver mills.

From this table the output of ore from the Central States, producing small quantities of silver and no gold, has been omitted. The output of zinc ore from the Eastern States is also omitted, as this zinc ore is reported to produce neither silver nor gold.

PERCENTAGE OF OUTPUT OF GOLD AND SILVER PRODUCED BY DIFFERENT PROCESSES.

Percentage of output of gold and silver produced by different processes, 1912–1917.

Process.	Percentage of total output.											
	Gold.						Silver.					
	1912	1913	1914	1915	1916	1917	1912	1913	1914	1915	1916	1917
Placers	24.8	24.9	25.2	22.7	25.0	25.8	0.2	0.2	0.2	0.2	0.2	0.2
Gold and silver mills:												
By amalgamation	22.3	21.5	20.9	22.8	21.5	20.9	1.2	.6	.4	.4	.4	.4
By cyanidation	30.9	31.2	31.4	30.4	28.1	29.5	17.8	19.7	22.1	22.1	18.3	16.3
By chlorination	.4	.3	.4	.5	.5	.2	......	......	......	......	......	......
Total milling	53.6	53.0	52.7	53.7	50.1	50.6	19.0	20.3	22.5	22.5	18.7	16.7
Smelting [a]	21.6	22.1	22.1	23.6	24.9	23.6	80.8	79.5	77.3	77.3	81.1	83.1
Total [b]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] Both crude ore and concentrates.

[b] Philippine Islands and Porto Rico excluded.

The placers produced about 25.8 per cent of the total output of gold, an increase of 0.8 per cent. The dredges produced 1.8 per cent less gold in 1917 than in 1916, and the combined placer yield from hydraulic, drift, and other surface methods was $1,300,000 less than in 1916. The decrease from placers was largely due to a smaller output from Alaska and Idaho. The percentage of output of silver credited to the placers is insignificant.

In the mills the amalgamation process showed a loss of 0.6 per cent of the total recovery of gold in 1917. This was due to the decrease in mining and milling in Colorado, California, and Nevada, which produce ores more amenable to treatment by amalgamation. The gold recovered by cyanidation showed an increase of 1.3 per cent following a decrease of 2.3 per cent in 1916. The chlorination process was used in only a few mills in California and the output of gold was only 0.2 per cent of the total recovery of gold, compared with 0.5 per cent in 1916. None of the Colorado plants used chlorination in 1917, and the total recovery of gold by that process in California mills amounted to $188,129.

GOLD AND SILVER PRODUCED AT MILLS, BY STATES.

Large quantities of concentrates from sulphide ores are now smelted and the increased application of the flotation process has resulted in decreased yield of gold and silver from cyanidation. Part of the flotation concentrates are cyanided and not shipped to smelters. This method was adopted by the Goldfield Consolidated Mines Co., which had retained part of the cyanide plant for treatment of tailings and the flotation concentrates.

It is stated in the annual report of the Goldfield Consolidated Mines Co. for 1917 that the treatment by cyanidation of concentrates recovered by flotation was not profitable in that such flotation concentrates must be subjected to a chloridizing roast prior to the treatment by cyanide. The flotation concentrates are now shipped to smelters.

The smelters, which had for three years been producing each year a slightly greater proportion of gold and a smaller proportion of silver, are to be credited in 1917 with about 23.6 per cent of the total output of gold and 83.1 per cent of the silver. The decrease in the per cent of gold in 1917 was due to the smaller quantity of gold recovered from crude ore smelted.

The bulk of the production of gold remains mainly from the gold mills, but in decreasing proportion. As shown by the table above the proportion of gold recovered by amalgamation, cyanidation, and chlorination has decreased from 53.6 per cent in 1912 to 50.6 per cent in 1917.

The following table shows in greater detail the ore treated and the output of gold and silver mills, by States, in 1917:

Gold and silver produced at mills in 1917, by States.[a]

State.	Ore and tailings treated.	Bullion recovered.				Percentage of gold and silver from all sources.			
		Amalgamation.		Cyanidation.		Amalgamation.		Cyanidation.	
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
	Short tons.	*Fine oz.*	*Fine oz.*	*Fine oz.*	*Fine oz.*				
Alaska	3,414,654	115,341	29,296	47,815	4,640	16.3	2.3	6.7	0.3
Arizona	266,478	1,875	1,701	118,762	252,652	.8	......	48.4	3.6
California[b]	2,015,012	376,089	83,142	22,650	29,937	38.7	4.7	2.3	1.7
Colorado	1,493,257	29,107	19,457	524,447	380,652	8.8	.3	68.4	5.2
Idaho	67,677	21,569	11,102	1,152	9,775	55.4	.1	3.0	.1
Montana	337,610	2,845	1,246	64,062	233,822	1.7	......	37.6	.5
Nevada	1,271,022	21,740	21,191	226,317	9,220,352	6.4	.2	67.2	81.8
New Mexico	123,824	14,867	2,256	11,404	655,181	28.8	.1	22.1	3.8
Oregon	135,718	10,039	57,160	25,194	36,237	13.9	45.5	34.9	28.8
South Dakota	[c]1,867,583	228,018	61,759	127,560	119,292	64.0	33.1	35.8	63.3
Texas	51,966	......	......	......	593,128	......	......	......	99.5
Utah	190	141	26	......	......	......	......	......	......
Washington	10,986	6,721	411	13	50	28.2	.2	......	......
Wyoming	20	15	6	......	......	8.2	.2	......	......
Appalachian States	20,214	314	38	102	29	22.2	......	7.2	......
Total, 1917	11,076,211	828,681	288,791	1,169,478	11,535,747	20.9	.4	29.4	16.3
Value	......	$17,130,357	$237,976	$24,175,256	$9,505,455	......	......	......	......
Total, 1916	11,393,838	964,589	348,177	1,260,172	14,432,378	21.5	.4	28.1	18.3
Value	......	$19,939,824	$229,097	$26,050,067	$9,496,505	......	......	......	......

---

[a] Porto Rico and Philippine Islands excluded.

[b] Recovered by chlorination, 9,100.74 ounces of gold and 283 ounces of silver in California. Value of gold recovered by chlorination was $188,129; that of silver, $233.

[c] Part of ore amalgamated followed by cyanidation of new tailings. Total ore and new tailings cyanided, 1,809,417 tons.

Figures corresponding to those in this table were collected and compiled for the entire United States by the Survey for the first time in 1911, and comparison for seven years can therefore now be made.

The total quantity of crude ore treated and old tailings re-treated in gold and silver mills was 11,076,211 short tons in 1917 against 11,393,838 tons in 1916, 11,878,287 tons in 1915, 9,849,085 tons in 1914, 9,401,856 tons in 1913, 9,677,360 tons in 1912, and 9,670,483 tons in 1911. In 1917 ores from Alaska and California treated at gold and silver mills amounted to about 50 per cent of the total quantity.

The great bulk of the ore treated, as shown, was milled in Alaska, California, South Dakota, Nevada, and Colorado, in the order named, and here the famous mills of the Homestake, Mother Lode, Grass Valley, Treadwell, Cripple Creek, Tonopah, and Goldfield mines are especially in evidence. Large numbers of smaller mills, however, mark the wide distribution of gold mining in these regions and in many other scattered districts.

The total yield of gold by amalgamation in the United States in 1917 was 828,681 fine ounces, valued at $17,130,357, against 964,589 ounces, valued at $19,939,824, in 1916. The output in 1917 was 376,089 ounces in California, 228,018 ounces in South Dakota, 115,341 ounces in Alaska, 29,107 ounces in Colorado, and 21,740 ounces in Nevada. Idaho showed the only increase, 3,000 ounces, in gold recovered by amalgamation.

The total yield of silver by amalgamation in 1917 was only 288,791 fine ounces, valued at $237,976, against 348,177 ounces, valued at $229,097, in 1916. The output came mainly from California, South Dakota, Oregon, Alaska, Nevada, and Colorado, in the order given, and consisted chiefly of silver alloyed with gold.

The total output of gold by cyanidation in 1917 was 1,169,478 fine ounces, valued at $24,175,256, against 1,260,172 ounces, valued at $26,050,067, in 1916. The output was 524,447 ounces in Colorado, 226,317 ounces in Nevada, 127,560 ounces in South Dakota, 47,815 ounces in Alaska, 118,762 ounces in Arizona, and 22,650 ounces in California in 1917. The only important increase in 1917 was that of Arizona, amounting to 55,318 ounces. The more important decrease was in Alaska, 32,522 ounces; California, 34,324 ounces; Nevada, 67,308 ounces.

The total yield of silver by cyanidation in 1917 was 11,535,747 fine ounces, valued at $9,505,455, against 14,432,378 ounces, valued at $9,496,505, in 1916. Nevada led, with the bulk of the output—9,220,352 ounces—and was followed by New Mexico with 655,181 ounces, Texas with 593,128 ounces, and Colorado with 380,652 ounces. The most notable losses were in Arizona, 395,730 ounces; New Mexico, 184,289 ounces; Colorado, 130,339 ounces; and Nevada, 2,081,509 ounces.

The quantity of gold recovered from ore treated by amalgamation decreased about 136,000 ounces in 1917 and that recovered from ores cyanided decreased about 90,000 ounces.

Of the gold-producing States, whose chief output is from milling ores, Alaska, California, and South Dakota still yield more gold by amalgamation than by cyanidation, whereas the latter process produces more gold than amalgamation in Colorado, Arizona, Nevada, Oregon, and Montana, and it produces much more silver in Arizona, Colorado, Montana, Nevada, New Mexico, South Dakota, and Texas. Oregon, Alaska, and California were the only States in which the recovery of silver by amalgamation exceeded that by cyanidation. Altogether amalgamation produced gold and silver valued at $17,368,107 from milling ores in 1917, against $33,680,711 produced by cyanidation from such ores in that year.

Of the total output of gold from all sources in 1917, amalgamation produced 16.3 per cent in Alaska, 38.7 per cent in California, and 64 per cent in South Dakota, and cyanidation produced 48.4 per cent in Arizona, 68.4 per cent in Colorado, 67.2 per cent in Nevada, 22.1 per cent in New Mexico, 35.8 per cent in South Dakota, and 37.6 per cent in Montana.

Of the total output of silver from all sources in 1917, amalgamation produced 33.1 per cent in South Dakota and 45.5 per cent in Oregon, and cyanidation produced 81.8 per cent in Nevada, 63.3 per cent in South Dakota, and 99.5 per cent in Texas.

QUICKSILVER AND POTASSIUM AND SODIUM CYANIDE CONSUMED IN CERTAIN STATES.

For details of the consumption of quicksilver in the amalgamation milling process and of potassium cyanide and sodium cyanide in the cyanidation process the reader is referred to the mines reports of the several Western States named in the prefatory note. Data as to consumption of these supplies are not yet furnished by a sufficient number of mining and milling companies to justify tabulation for the entire United States. It has been estimated by H. D. McCaskey that the consumption of quicksilver in the amalgamation process in the United States (including Alaska) for the period 1911 to 1917, inclusive, has varied between 90,000 and 100,000 pounds annually. The consumption at mills treating ore and by dredging and other methods of placer mining are given in the separate chapter entitled "Quicksilver in 1917," prepared by F. L. Ransome and published elsewhere in Mineral Resources for 1917.

In the following tables, compiled by V. C. Heikes, of the United States Geological Survey, some details are given for the consumption of quicksilver and of cyanide in the recovery of gold and silver in six Western States from 1911 to 1917, inclusive.

Quicksilver consumed in certain Western States, 1911–1917.

State and year.	Number of mills using quicksilver.	Ore and tailings treated.	Total quicksilver.[a]	Quicksilver consumed (average per ounce of gold and silver bullion).
Arizona:		*Short tons.*	*Pounds.*	*Pounds.*
1911	26	46,833	1,362.00	0.086
1912	40	28,028	1,414.30	.098
1913	18	36,338	2,912.68	.158
1914	22	44,808	1,802.00	.116
1915	32	34,360	547.00	.063
1916	13	17,568	645.00	.040
1917	9	21,100	205.00	.057
Idaho:				
1911	35	72,210	1,648.00	.057
1912	43	34,609	700.00	.020
1913	40	28,258	254.00	.019
1914	29	25,877	598.00	.042
1915	36	46,423	1,040.00	.027
1916	36	66,304	1,183.00	.039
1917	27	63,884	1,035.00	.032
Montana:				
1911	24	61,767	898.00	.031
1912	17	48,837	783.59	.047
1913	23	14,508	289.57	.077
1914	18	29,983	408.00	.074
1915	24	28,504	371.00	.051
1916	18	18,959	206.00	.026
1917	13	8,925	167.00	.040
Nevada:				
1911	56	781,463	4,753.00	.012
1912	49	388,714	6,636.73	.044
1913	39	360,579	5,054.73	.051
1914	42	250,408	6,826.00	.063
1915	47	211,729	4,367.00	.038
1916	36	131,891	2,111.00	.034
1917	32	67,359	839.00	.020
Utah:				
1911	6	5,020	105.00	.058
1912	4	588	27.70	.145
1913	3	1,157	71.81	.107
1914	2	533	20.00	.108
1915	3	1,399	30.00	.020
1916	4	703	15.00	.039
1917	2	190	5.00	.030
Washington:				
1911	5	11,846	526.00	.197
1912	9	4,609	121.00	.043
1913	9	768	43.82	.038
1914	5	2,146	43.00	.039
1915	3	1,286	28.00	.031
1916	5	11,495	317.00	.027
1917	4	10,976	185.00	.026

State.	1911	1912	1913	1914	1915	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Arizona	1,362.00	1,414.30	2,912.68	1,802.00	547.00	645.00	205.00
Idaho	1,648.00	700.00	254.00	598.00	1,040.00	1,183.00	1,035.00
Montana	898.00	783.59	289.57	408.00	371.00	206.00	167.00
Nevada	4,753.00	6,636.73	5,054.73	6,826.00	4,367.00	2,111.00	839.00
Utah	105.00	27.70	71.81	20.00	30.00	15.00	5.00
Washington	526.00	121.00	43.82	43.00	28.00	317.00	185.00
	9,292.00	9,683.32	8,626.61	9,697.00	6,383.00	4,477.00	2,436.00

[a] Partly estimated.

Quicksilver consumed in Colorado in 1917 amounted to 3,800 pounds, in New Mexico to 175 pounds, and in South Dakota to 13,199 pounds.

Potassium and sodium cyanides consumed in certain Western States, 1913–1917, in pounds.

State.	Potassium cyanide.					Sodium cyanide.				
	1913	1914	1915	1916	1917	1913	1914	1915	1916	1917
Arizona			715		580			226,427	216,841	157,381
Colorado	659,374	35,800	39,600	22,200	135,680	260,589	935,589	1,088,592	1,082,617	746,428
Idaho			2,894	3,431	1,268			3,725	700	3,728
Montana			1,003	13,305				162,377	190,249	158,215
Nevada			13,514	140,328	130			3,050,092	2,179,995	1,925,038
New Mexico	1,415		29,000			190,190	237,511	216,709	176,525	123,500
South Dakota	113,727	89,649	11,477	5,300		388,961	425,397	458,300	419,210	384,938
Utah			36	1,200				5,320		37,000
Washington			1,200					3,400	2,380	
	774,516	125,449	99,439	185,764	137,658	839,740	1,598,497	5,214,942	4,268,517	[a]3,536,228

[a] Mines in Texas used 37,000 pounds of sodium cyanide in 1917.

Potassium and sodium cyanides consumed in certain Western States, 1911–1917.

State and year.	Number of mills using cyanidation process.	Ore and tailing treated.	Total consumption of cyanide.[a]	Cyanide consumed.	
				Average per ton of ore and tailing.	Average per ounce of gold and silver.
Arizona:		*Short tons.*	*Pounds.*	*Pounds.*	*Pounds.*
1911	9	152,815	115,877	0.758	0.919
1912	9	202,285	129,987	.642	.973
1913	11	208,591	189,291	.907	1.128
1914	13	294,827	264,969	.900	.369
1915	17	267,639	227,142	.850	.275
1916	9	276,623	216,841	.780	.300
1917	10	227,648	157,961	.69	.430
Idaho:					
1911	10	64,510	181,808	2.818	4.300
1912	5	54,477	161,156	2.958	3.300
1913	6	37,303	94,475	2.533	3.400
1914	10	12,094	32,529	1.800	2.530
1915	10	4,676	6,619	1.410	.440
1916	8	3,469	4,631	1.33	.38
1917	4	3,793	4,996	1.30	.45
Montana:					
1911	27	203,912	91,657	.449	.610
1912	21	184,487	93,344	.506	.913
1913	24	170,348	116,422	.683	.958
1914	13	192,235	151,738	.789	.921
1915	18	330,140	163,380	.494	.449
1916	18	381,560	203,554	.53	.69
1917	15	328,685	158,215	.48	.53
Nevada:					
1911	41	1,083,883	2,352,961	2.170	.313
1912	37	1,179,365	2,618,424	2.220	.252
1913	29	1,326,793	2,798,224	2.109	.228
1914	36	1,240,337	3,217,886	2.365	.258
1915	37	1,479,898	3,063,606	2.070	.239
1916	38	1,367,249	2,320,328	1.70	.20
1917	32	1,203,665	1,925,168	1.60	.20
Utah:					
1911	6	268,691	205,041	.763	1.450
1912	6	170,809	203,721	1.193	2.380
1913	6	81,940	70,238	.857	.956
1914	4	17,113	7,396	.432	.607
1915	3	12,064	5,356	.440	.839
1916	2	720	1,200	1.67	4.48
1917					
Washington:					
1911	3	17,381	9,700	.544	2.605
1912	4	16,703	36,517	2.186	.993
1913	2	20,410	32,090	1.572	.993
1914	2	22,387	48,820	2.180	.999
1915	4	1,746	4,600	2.600	.916
1916	1	1,207	2,380	1.97	3.12
1917					

Potassium and sodium cyanides consumed in certain Western States, 1911–1917—Contd.

State.	1911	1912	1913	1914	1915	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Arizona	115,877	129,987	189,291	264,969	227,142	216,841	157,961
Idaho	181,808	161,156	94,475	32,529	6,619	4,631	4,996
Montana	91,657	93,344	116,422	151,738	163,380	203,554	158,215
Nevada	2,352,961	2,618,424	2,798,224	3,217,886	3,063,606	2,320,328	1,925,168
Utah	205,041	203,721	70,238	7,396	5,356	1,200	....
Washington	9,700	36,517	32,090	48,820	4,600	2,380	....
	2,957,044	3,243,149	3,300,740	3,723,338	3,470,703	2,748,934	2,246,340

[a] Partly estimated.

It has not been possible to obtain a complete report showing the total consumption of potassium cyanide and sodium cyanide used in the recovery of gold and silver in the United States in 1917. If the quantity used in California, Alaska, and Oregon is added to the 3,710,886 pounds reported to have been used in other Western States the estimated total consumption was probably several hundred tons less than the estimated quantity, 2,600 tons, consumed in 1916.

The figures given indicate the elimination of the use of potassium cyanide in the recovery of gold and silver, for only about 69 tons were used in 1917 and this was probably from old stocks at mines. The growing scarcity of potassium cyanide necessarily increased the use of sodium cyanide. The domestic supply of sodium cyanide was sufficient to supply the domestic consumption. As the quantity of bullion recovered was less in 1917 than in 1916, however, the quantities of quicksilver and of cyanide used were less. The quantity of cyanide used per ton of ore or tailings treated and the quantity of gold and silver recovered per pound of cyanide show considerable variations. These variations are doubtless due in part to greater efficiency in large milling plants in some of the States but are mainly caused by the difference in the character and varying metal content of the ores treated.

ANTIMONY.

By **Edson S. Bastin.**

THE ANTIMONY SITUATION.

The United States is dependent upon three classes of material as sources of antimony or its alloys or compounds. (1) Antimony ore is imported from China (direct or via Japan), Bolivia (via Chile and Peru), and Mexico, and small quantities of ore are produced in the western United States. (2) Liquated antimony sulphide, also known as "crude antimony," "needle antimony," and antimony matte, is imported in small quantity from China. This material is produced by submitting the ores of the natural antimony sulphide, stibnite, to a red heat sufficient to melt but not to decompose it, and the metallic sulphide is then run into molds and allowed to cool. (3) Metallic antimony, known as antimony regulus, is imported from China, Japan, and Mexico and is produced in small quantity in the United States from both foreign and domestic ores. The metallic antimony imported from Japan is derived mainly from the refining of Chinese ore or "crude." A fourth class of material which should also be mentioned is antimonial lead, carrying from 12 to 18 per cent of antimony. Any of the three classes of materials noted above may enter into this product, but it is derived mainly from lead ores, most of them of the antimonial variety.

The United States has always been dependent mainly on foreign sources for its supplies of antimony. China and Japan have been the principal contributors, although Mexico and Bolivia have also made considerable contributions. This dependence is a reflection of the higher wage scale in this country as compared with certain foreign countries, particularly China, but it is due also to our comparative poverty in antimony resources, although little information of a quantitative nature has been collected concerning these resources, and they may be greater than has generally been assumed.

For many years prior to the European war the New York prices of the ordinary grades of metallic antimony ranged from 6 to 8 cents a pound; the imports, calculated as antimony metal, ranged from about 4,000 to 7,500 short tons; and the production from ores mined in this country was negligible. With the outbreak of the war the price of antimony began to rise rapidly because of the need of the metal in the manufacture of shrapnel bullets, and as uncertainty was felt as to the continuance of supplies from abroad, numerous mines in the Western States and several in Alaska were put into operation. By the end of 1915 the New York price had reached 40 cents a pound, and by March, 1916, it attained its maximum, for ordinary grades, of about 44 cents. These high prices drew out in the United States in

1915 a production of ore carrying about 2,100 short tons of antimony and in 1916 ore containing about 1,770 short tons of antimony. The high prices also greatly stimulated imports, as is shown in Plate V, and this forced down the prices of ordinary grades to 11 or 12 cents late in 1916 and made it impossible for most of the new domestic mines to operate at a profit. By the end of 1916 many of these mines had closed and others were in a precarious condition.

In anticipation of the entrance of the United States into the war there was a notable recovery in prices, ordinary grades reaching about 33 cents in April, 1917. This increase again stimulated imports (see Pl. V), which proved to be far in excess of the demands and not only forced a rapid decline in price to a fairly constant level of about 14 cents during the last half of 1917 but also built up large stocks in bonded warehouses (see fig. 11) and in the hands of dealers and consumers. Stocks in bonded warehouses alone, which were negligible early in 1917, amounted to more than 10,000,000 pounds at the end of the year. The decline in prices in 1917 dealt a final blow to domestic antimony mining, which during the year produced ore carrying only about 390 short tons of metallic antimony. Before the end of the year nearly all domestic mines had ceased operation. The experience of some of the larger operators seems to have indicated that mining and treatment of domestic ores could not be profitably conducted in 1917 unless the market price for ordinary grades of antimony was at least 20 cents.

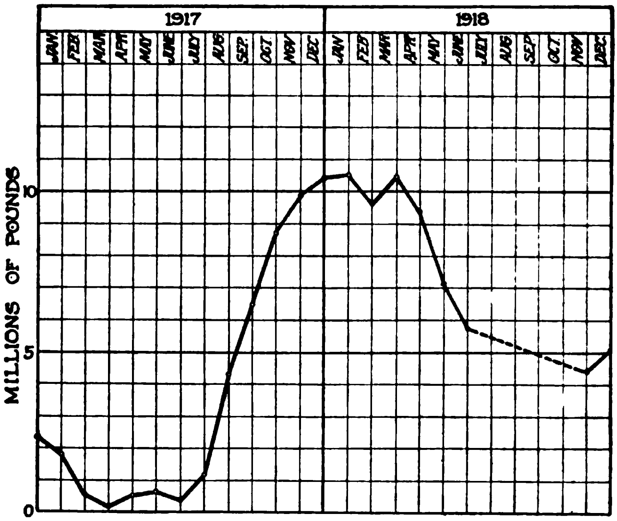


FIGURE 11.—Diagram showing stocks of metallic antimony in bonded warehouse at end of each month in 1917 and 1918, as reported by the Bureau of Foreign and Domestic Commerce.

In view of the large differential between the cost of production of antimony here and in China a return to an almost complete dependence upon foreign supplies is to be expected with the return of normal conditions. The fostering of a domestic antimony industry through protective tariff legislation involves grave considerations of public policy, including a careful weighing of the interests of domestic

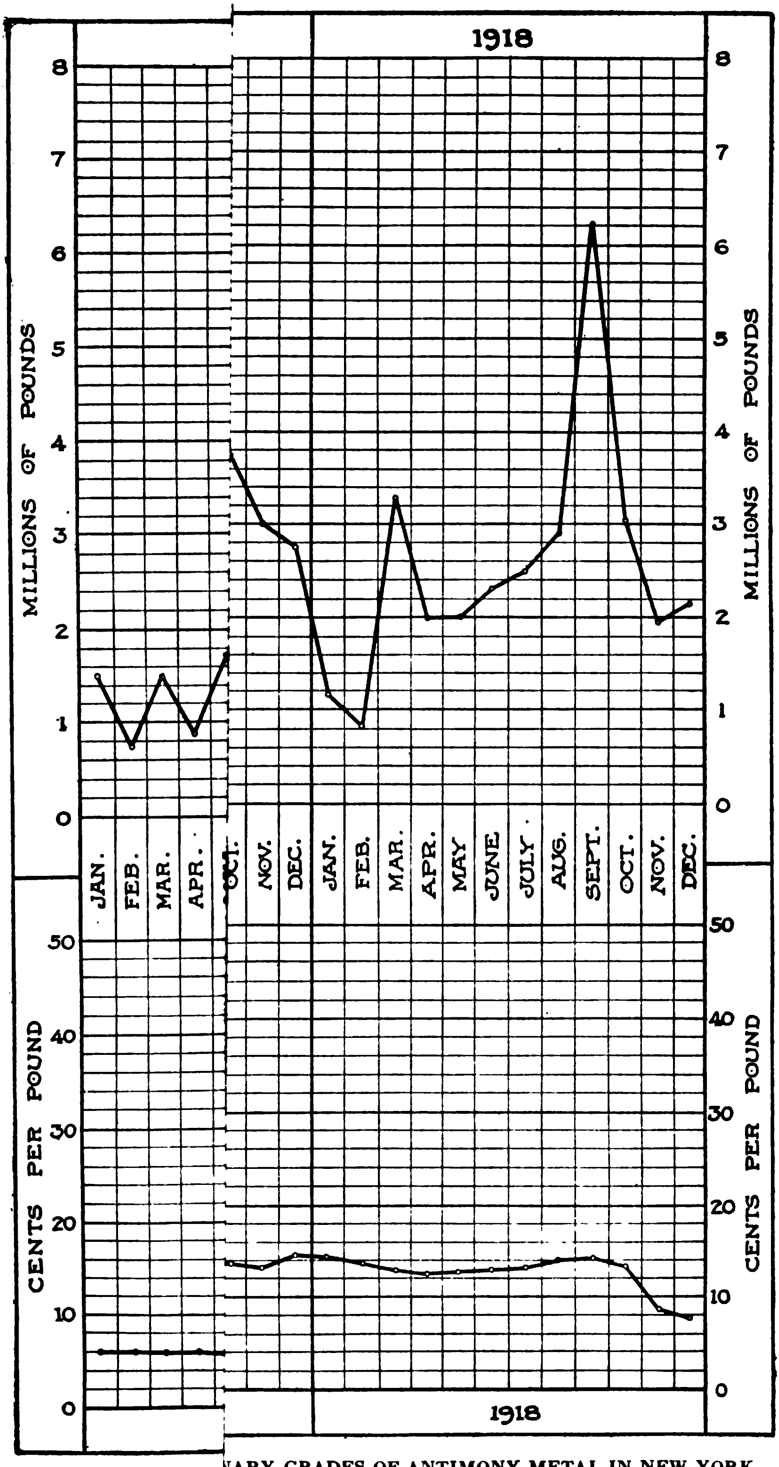


DIAGRAM SHOWIN ARY GRADES OF ANTIMONY METAL IN NEW YORK

consumers as well as producers and of the commercial and political importance of our foreign trade relations.

USES.

Peace uses.—Metallic antimony unalloyed has few industrial uses. In the form of fine powder, known as "iron black," it is used for producing the appearance of polished steel on articles made of papier-mâché or pottery. For these purposes it is precipitated by the action of metallic zinc on an acid solution of antimony salts. Antimony alloys readily with most heavy metals, and the alloy is harder than the two pure metals. Most of these alloys possess the property of slight expansion on solidifying. Type metal is an alloy of antimony, lead, and tin; babbitt, antifriction, or bearing metal is usually an alloy of antimony, tin, and copper. Britannia metal, also known as "white metal," is an alloy of antimony, tin, and copper, with some zinc and, rarely, small quantities of other metals. It is used in making cheap domestic tableware, teapots, and spoons. Antimony alloys find minor utilization in battery plates, toys, cable coverings, and siphon tops. Small quantities of antimony enter into certain brasses and aluminum alloys. Lead-antimony alloy, or "hard lead," is used in making acid-resisting valves.

White antimony oxide, mainly the tetraoxide (Sb_2O_4), is used for making opaque white enamel and other sanitary ware. In this use antimony oxides compete with tin oxide. Antimony oxide, mainly trioxide, is used as a coloring agent in the manufacture of glass, as it is more readily fusible than tetraoxide and does not impart opacity to the glass. Antimony oxides are further used as paint pigments.

The red sulphides of antimony are used in vulcanizing and coloring red rubber and also as paint pigments. The natural antimony trisulphide, stibnite, enters into the composition of safety matches or of the compound which is put on the match box.

Antimonate of lead, containing an excess of lead oxide, known as "Naples yellow," is used in oil paints and in the glass and ceramic industries. Tartar emetic (double tartrate of antimony and potassium) and antimony fluoride are employed as mordants in dyeing. Tartar emetic and antimony trioxide are employed medicinally.

War uses.—Antimonial lead carrying 12 to 13 per cent of antimony is employed in the manufacture of shrapnel bullets. Antimony sulphide is almost universally used as a constituent of primers in shells and cartridges, a utilization which is of the utmost importance but requires only very small amounts of material, not more than a few hundred tons being so used in the United States during 1918. Specifications for antimony sulphide for these purposes have been unnecessarily exacting, for recent investigations[1] have demonstrated that most of the material that has been successfully used in primers has contained from 80 to 85 per cent of antimony sulphide (Sb_2S_3), 2 to 3 per cent of siliceous material insoluble in sulphuric acid, and as much as 18 per cent of antimony combined with oxygen either as an oxide or as an oxysulphide. The presence of lead and iron as impurities is probably not deleterious, as was formerly supposed, for excellent primers have been prepared by substituting lead sulphide or iron sulphide for antimony sulphide. These investigations relieve any apprehension as to an adequte supply of antimony material suitable for primers. They show that readily obtainable commercial grades of antimony sulphide are adequate for this purpose and that probably other sulphides could, if necessary, be substituted for antimony sulphide.

---

[1] Cushman, A. S., Antimony sulphide as a constituent in military and sporting arms primers: Jour. Ind. and Eng. Chemistry, May, 1918, pp. 376–383.

Antimony sulphide as a powder is used in the charges of some shells to produce on explosion a dense white smoke, which is of service in range finding.

SUPPLY OF ANTIMONY.

In estimating the supplies of antimonial materials available for domestic use in 1917 ores are excluded from consideration in order to avoid confusion and duplication, inasmuch as the recoverable antimony content of both foreign and domestic ores eventually appears in the records of production of metal, alloys, or compounds.

Antimony metal available in 1917.[1]

		Short tons.
Stocks in bonded warehouses Dec. 31, 1916		1,155
Production from domestic ores		258
Production from foreign ores		2,182
Imports (general)		17,824
		21,419
Stocks in bonded warehouses Dec. 31, 1917	5,201	
Exports	495	
		5,696
Antimony metal available for private stocks or consumption in 1917		15,723

Antimony alloys, mainly antimonial lead, available in 1917.

	Gross weight (short tons).	Antimony content (short tons).
Production of by-product antimonial lead [a]	18,646	2,759
Production of antimonial lead from antimony ores and lead ores or scrap lead	2,283	348
Recovery from secondary metals and drosses [b]		4,961
Imports of type metal for consumption	None.	None.

[a] Produced from lead skimmings as by-product of lead smelting.

[b] Recovered mainly as purified alloys, not as antimony metal. Gross weight not reported.

The domestic production of antimony oxide and other compounds in 1917 has not been reported; the imports for consumption amounted to 10 short tons, gross weight.

MINE PRODUCTION OF ANTIMONY ORES.

The production of antimony ores in the United States in 1917 was confined to the Western States and Alaska. Nevada led, with a production of about 870 short tons, and was followed by Alaska, with less than 100 tons, and by California, Idaho, and Utah, with less than 50 tons each. The total reported for the United States was about 1,060 short tons having an average tenor of about 37 per cent metallic antimony. The total antimony content was about 390 short tons, of which perhaps 80 per cent, or 312 short tons, was recoverable.

---

[1] Antimony regulus or metal and very small quantities of antimony sulphide or "crude" antimony.

The mine production in 1917 was less than one-fourth of that in 1916 (4,500 short tons, with a metallic antimony content of 1,770 short tons). The decline was due to the downward trend in prices, which began early in April, as is shown in Plate V.

Alaska.—Only one property in Alaska produced antimony ore in 1917; this was the Scrafford, in the Fairbanks district. The ore, most of which assayed 45 to 55 per cent of antimony oxide, was shipped to Seattle. It was recovered by sluicing old dumps, no new mining being undertaken.

Arkansas.—At the mine of the American Star Antimony Co. near Gillham, in Sevier County, Ark., some ore was mined in 1917, but not sold. Late in the year the plant was closed down.

California.—Less than 50 tons was reported as produced in California in 1917, from the Lone Tree mine, near Hollister, San Benito County, and from a prospect in Kern County.

Idaho.—Three properties in Shoshone County, Idaho, reported operations in 1917, but their aggregate output of ore was less than 50 tons. The Coeur d'Alene Antimony Mining Co., whose office is at Kellogg, operated a mine in the valley of Pine Creek, in the Yreka district. In February, 1918, this company reported that a concentrating plant was in course of erection and that it was planned to recover the metal from the concentrates by electrolytic treatment. The Star Antimony Mining Co., with office at Kellogg, also mined a few tons of ore in the same district. Ore from this district was shipped exclusively to the Magnolia Metal Co. at Matawan, N. J.

In 1917 a reduction plant was in erection at the mine of the Idaho Antimony Mining Co. in the Yellow Pine district, Idaho County, but no antimony was marketed during the year.

Development work was done at the Orlando Leasing Co.'s property in the Lelande district, and also on a property operated by Charles A. Pearsons, of Beeler, both in Shoshone County. The Hougland mine, 8 miles from Burke, formerly a large producer, was idle during 1917. The deposits are said to be flat-lying or "blanket" veins worked by tunnels. At one time an oxide plant was operated at this mine.

Nevada.—Nevada produced about 870 tons of antimony ore in 1917 out of the total of 1,060 tons reported for the entire United States. The production came mainly from Humboldt and Lander counties, although small quantities were mined in White Pine County. As in previous years the Sutherland mine, 5 or 6 miles from Lovelock, Humboldt County, was one of the principal producing properties, but it was worked by lessees. The ore was shipped mainly to the Nichols-Layng Chemical Co., of San Francisco.

The National Antimony Co. stated in February, 1918, that it was erecting a plant for the production of antimony oxides at Mill City. Some ore was mined at its property in the Star district, Humboldt County, during the year.

In Lander County the mines of Antonio Borrego, Joseph Bray, and J. F. Murphy, in the Reese River district, Toyabe Range, were operated, and the output was shipped to Matawan, N. J. The Antimony King mine, in the same district, was operated by the Nichols-Layng Chemical Co., and the output was shipped to the works of this company at San Francisco.

Utah.—The Stibnite Mining Co., with office at Ogden, produced a small quantity of high-grade ore (assaying 60 to 66 per cent Sb_2O_3) from its mine in Bill Lewis Canyon, 3½ miles from Brigham City, Box Elder County. The ore was shipped to the Magnolia Metal Co., Matawan, N. J.

SMELTER PRODUCTION OF METALLIC ANTIMONY.

The production of metallic antimony in the United States in 1917, at the four plants mentioned below, amounted to 258 short tons from domestic ores and 2,182 short tons from imported ores, a total of 2,440 short tons. This is the first year for which figures of smelter production of metallic antimony have been obtained. The value of this antimony, computed on the basis of an average price of 20.7 cents a pound, or $414 a short ton, in New York City, for ordinary grades, is $1,010,160.

Smelters engaged in the production of metallic antimony in the United States in 1917 were the following:

Magnolia Metal Co., office at 113 Bank Street, New York City; plant at Matawan, N. J. This company has been a large user of domestic as well as foreign ores.

The Antimony & Compounds Co. of America, Highland Park, New Brunswick, N. J. This company, which is closely associated with the Société des mines de La Lucette et Le Genest, the principal French producer of antimony, established a plant at Piscataway, N. J., early in 1917. The plant has depended mainly on foreign ores.

Nichols-Layng Chemical Co., San Francisco, Calif.; treats only domestic ores.

Western Metals Co., Los Angeles, Calif. Plant at San Pedro, near Los Angeles. The plant treated mainly Bolivian and Mexican ores.

SMELTER PRODUCTION OF ANTIMONIAL LEAD.

The production of antimonial lead from lead skimmings as a by-product of the lead-smelting industry is tabulated for recent years in the chapter dealing with lead from figures collected by C. E. Siebenthal, of the United States Geological Survey. In 1916 and 1917 this production was as follows:

By-product antimonial lead produced in the United States from both foreign and domestic ores, 1916–17.

	Gross weight (short tons).	Antimony content (short tons).	Value of antimony content.[a]
1916	24,038	3,496	$1,775,968
1917	18,646	2,759	1,142,226

[a] Calculated on basis of average yearly price of 25.4 cents a pound, or $508 a short ton, in 1916, and of 20.7 cents a pound, or $414 a short ton, in 1917 for ordinary grades in the New York market.

In addition to the production recorded above 2,283 short tons of antimonial lead, valued at $144,072 and containing 348 tons of antimony, was produced from the smelting of foreign and domestic antimony ores with lead ores or scrap lead.

In obtaining this product there were used 345 short tons of antimony ores from Mexico and South America and 563 tons from Alaska and the western United States.

RECOVERY OF SECONDARY ANTIMONY.

During 1917 4,961 short tons of antimony was recovered from old alloys, scrap, and dross. Practically all of this was recovered in the form of alloys, not as metallic antimony. (See p. 656.)

Antimony content of secondary alloys recovered from old alloys, scrap, and dross, 1913–17.

Year.	Quantity (short tons).	Value.[a]
1913	2,705	$401,963
1914	2,646	444,844
1915	3,102	1,811,568
1916	4,480	2,270,016
1917	4,961	2,061,700

[a] Values calculated at average yearly price for ordinary brands of antimony as published by the American Metal Market.

IMPORTS.

The accompanying statistics of imports are taken from the reports of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, long tons being recalculated to short tons. The imports are reported as (1) imports for consumption, including merchandise entered for immediate consumption or withdrawn from bonded warehouses for consumption, and (2) total imports. Only total imports are listed by countries of origin.

In contrast to the small domestic production of 1,060 short tons of antimony ore in 1917, the imports were nearly ten times as great, amounting to 10,370 short tons. Furthermore, the imported ore averaged 57 per cent antimony, as against 37 per cent for the domestic ore.

Total imports [a] of antimony into the United States in 1917.

Country.	Antimony ore.			Antimony metal.[b]	
	Quantity (short tons).	Antimony content.			
		Quantity (pounds).	Value.	Quantity (pounds).	Value.
Canada	126	105,077	$15,762	190,000	$24,879
Newfoundland and Labrador	22	30,136	1,985		
Mexico	2,116	1,434,403	76,712	4,126,659	416,866
Argentina [c]	596	632,662	55,514		
Chile [c]	4,098	5,131,569	507,463		
Peru	44	27,570	3,636		
Colombia	2	2,356	255		
Honduras	3	4,785	1,563		
China	2,949	4,060,353	331,504	11,324,846	1,333,541
Hongkong [d]				859,835	101,568
Japan				18,677,597	2,333,745
England				470,176	87,081
Portugal	302	390,282	27,870		
Portuguese Africa	112	101,250	9,734		
	10,370	11,920,443	1,031,998	35,649,113	4,297,680

[a] Includes large quantities of antimony metal that went into bonded warehouse and that are not included in the table of imports for consumption.

[b] Includes small quantities of liquated antimony sulphide, known in the trade as "crude antimony," "antimony matte," or "needle antimony."

[c] Imports credited to Chile originated mainly in Bolivia; those credited to Argentina may also be Bolivian.

[d] Nearly all the imports of antimony ore and metal from Hongkong and Japan are of Chinese origin. Some of the material credited to other countries is possibly also of Chinese origin, having been transshipped in a foreign port.

The total imports show a notable increase in 1917 over 1916, when the ore imports amounted to 7,764 short tons, having an antimony content of 9,485,423 pounds, and the metal imports aggregated 19,749,830 pounds.

It is noteworthy that ore imports from Mexico were considerably larger in 1917 than in 1916 (1,339 short tons) and that ore imports from China also increased (1,048 short tons in 1916). Metal imports from China and Hongkong combined were about the same as in 1916, but metal imports from Japan were nearly three times those in 1916 (6,869,293 pounds). Noteworthy imports of metal also came from Mexico in 1917, although in 1916 none were brought in.

As shown in Plate V, the imports suddenly increased just after the entrance of the United States into the war, reached a maximum in August, and declined rapidly during the remainder of the year.

Antimony imported and entered for consumption, 1913–1917.

Year.	Antimony ore.[a]			Liquated antimony sulphide.[b]		Metallic antimony.[c]		Antimony oxide and other compounds.[d]	
	Quantity (short tons).	Antimony content (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1913	2,860	2,007	137,361	3	419	6,240	798,581	984	$117,169
1914	1,791	1,254	71,341	49	4,004	6,555	736,420	1,372	315,001
1915	2,494	1,544	332,125	....	....	7,354	2,660,830	423	132,193
1916	7,840	4,622	1,072,340	....	....	7,064	3,548,507	243	109,832
1917	9,003	5,831	1,006,884	796	128,660	11,285	2,829,159	10	5,368

[a] Classified in tariff classification as "Antimony ore and stibnite containing antimony."
[b] Classified in tariff classification as "Antimony matte, containing not more than 10 per cent of lead."
[c] Classified in tariff classification as "Antimony regulus or metal."
[d] Classified in tariff classification as "Antimony, oxide, salts, and compounds of."

For years large quantities of antimonial lead were imported into the United States as type metal, for which it is largely used, but since 1911 these imports have declined. The following table is compiled from the records of the Bureau of Foreign and Domestic Commerce:

Type metal imported and entered for consumption, 1906–1917.

Year.	Type metal.		Assumed antimony content.		Year.	Type metal.		Assumed antimony content.	
	Quantity (short tons).	Value.	Quantity (short tons).	Percentage.		Quantity (short tons).	Value.	Quantity (short tons).	Percentage.
1906	9,801	$900,608	1,853	18.9	1912	291	$18,668	52	17.2
1907	7,416	932,027	1,369	18.5	1913	284	20,098	50	17.6
1908	2,055	156,847	422	20.5	1914	755	45,373	94	12.4
1909	6,997	532,108	1,327	19.0	1915	1,384	107,607	172	12.4
1910	6,697	485,493	1,109	16.6	1916	581	83,816	119	20.5
1911	4,195	310,658	727	17.3	1917	None.	....	None.	....

The customs returns give only the lead content of imported type metal, and the figures given above are based on the assumption that the remainder is practically all antimony, but this assumption is wholly arbitrary, for imported type metal contains as much as 2 per cent of impurities, such as iron, arsenic, and copper. The antimony content is therefore probably too large by some quantity less than or approximately equal to 2 per cent of the total quantity of type metal, and the correct percentage is correspondingly lower.

EXPORTS.

Exports of metallic antimony[1] as recorded under "Exports of foreign merchandise" in the reports of the Bureau of Foreign and Domestic Commerce amounted to 989,477 pounds, valued at $169,260, in 1917, as against 3,018,251 pounds, valued at $761,045, in 1916. The exports in both years went mainly to Canada. No exports of antimony ore were recorded in 1917.

STOCKS.

Stocks of metallic antimony in bonded warehouses as reported by the Bureau of Foreign and Domestic Commerce were small during the first half of 1917, amounting on June 30 to only 322,811 pounds. During the last half of the year, as shown in figure 11, they increased very rapidly because of low prices and market stagnation, and on December 31 they amounted to 10,401,682 pounds.

PRICES.

The average New York prices for the highest grades of metallic antimony for the last 23 years, in cents per pound, are given by the Engineering and Mining Journal as follows:

1895	7.56	1903	6.00	1911	7.54
1896	6.65	1904	6.37	1912	7.76
1897	6.75	1905	10.25	1913	7.52
1898	8.69	1906	21.73	1914	8.76
1899	9.43	1907	14.84	1915	30.28
1900	9.50	1908	8.00	1916	25.37
1901	8.25	1909	7.47	1917	20.69
1902	6.12	1910	7.39		

For the ordinary grades of metallic antimony the fluctuations in average monthly prices during the five years 1914 to 1918 are shown in Plate V.

FOREIGN SOURCES.

CHINA.

The following statement in regard to the Chinese antimony industry is quoted from a report from the United States commercial attaché at Peking dated September, 1918:[2]

> China at present supplies the greater part of the world's demand. Sixty-two per cent of the American imports of antimony in 1916 came from China. It is produced in Hunan, Kwangtung, and southwestern China, 95 per cent coming from Hunan, which possesses the purest ores, practically free from arsenic and carrying from 20 to 64 per cent of antimony. Smelting is done at Changsha, Hankow, and Wuchang. The Wah Chang Co. (Chinese) owns the French patent rights for Hunan for the Herrenschmidt process for the treatment of low-grade sulphide ores and also has a Chinese Government monopoly for a limited term of years for producing regulus in Hunan Province. Antimony crude (concentrated antimony sulphide containing between 65 and 70 per cent of antimony metal) is the usual form in which antimony is marketed in China. The regulus assays at 98 to 99.8 per cent pure. In 1917 China

---

[1] "Matte, regulus, or metal," in Bureau of Foreign and Domestic Commerce classification.
[2] Commerce Repts., Nov. 27, 1918, p. 787.

exported 15,000 long tons of regulus, 20,000 tons of crude, and 4,000 tons of ore. The ports of export are Hankow, Shanghai, and Hongkong. The regulus is shipped in boxes, 13⅓ pounds to a box.

The conditions of the antimony industry in Hunan, the principal producing Province, during 1917 are described at some length in a report from the United States consul at Changsha,[1] from which the following extracts are quoted:

> While antimony continued to be the most important product of the mines of Hunan in the business of the Province during the year 1917, the production fell off and exports decreased by reason of the return to a more or less normal condition in the price. The customs statistics for 1917 give the following total exports from the port of Changsha to all countries: Antimony, crude, 42,665,733 pounds, valued at $2,252,807; antimony ore, 201,600 pounds, valued at $9,394; and antimony regulus, 29,608,267 pounds, valued at $3,258,712.
>
> With the fall in the price of antimony, smelters shut down and many of the mines that had been operating as speculations were closed.

This report gives also a detailed description of the operations of the Wah Chang Mining & Smelting Co., the principal antimony producer of the district.

JAPAN.

Since the beginning of the European war Japan has done a large business in Chinese antimony, and in 1917 the United States received more antimony from Japan than from any other single source. Japan has some antimony resources of her own, the development of which began in 1876 and for a number of years grew rapidly, the value of the production fluctuating from $50,000 to $120,000 annually. On account of growing scarcity of good ores and the low price of antimony domestic mining then declined, and it received its final blow in 1897, when the rich mines in Hunan Province, in China, were opened. Since then the Japanese have been unable to compete with the Chinese in antimony mining but have smelted some Chinese ore and matte.

With the beginning of the European war Japan began to import large quantities of antimony ore, matte, and metal from China and to make greatly increased exports, mainly as refined metal but to some extent in munitions. Her total exports of metallic and "crude" antimony increased from about 440 short tons in 1912 to about 4,750 short tons in 1914 and 15,700 short tons in 1917.[2]

Japan's smelting and transportation capacities have greatly facilitated the supplying of the Allies with their antimony requirements during the war, but the Chinese have during the same period greatly enlarged and extended their facilities for treating their antimony ores and may now be in a position to supply direct most of the normal peace needs of their foreign customers.

MEXICO.

United States imports of antimony ore and metal from Mexico in 1917 are shown in the table on page 659. These figures indicate a notable increase over 1916, when no imports of metal were recorded and when the imports of ore were 1,339 short tons (2,678,000 pounds), having an antimony content of 1,048,387 pounds.

At Catorce, on the National Railway of Mexico, in the State of San Luis Potosi, and at Charcas, a few miles farther south in the same

---

[1] Commerce Repts., May 21, 1918, pp. 699-703.

[2] From statistical returns of the Department of Finance of the Empire of Japan.

State, are the deposits of the Republican Mining Co. (Cookson interests), an English concern. The ore is smelted at Wadley, near Catorce.

Another antimony mine in the State of San Luis Potosi,[1] 8 miles east of Maroma station on the National Railway of Mexico, was operated during 1917 by William Dingwall, of San Antonio, Tex. Operation was somewhat irregular, owing to disturbance by bandits. The ore mined in 1917 was mainly oxide ore carrying an antimony content varying from 25 to 40 per cent. It is transported on pack mules to Maroma station and shipped by rail to the Metals Refining Co. at Hammond, Ind., where it is used in the production of antimonial lead.

In the State of Sonora[2] antimony ores were mined during 1917 by Miller & Thompson, 617 Pacific Building, San Francisco. The mine is in the Alter district, close to the Gulf of California and near a locality known as Antimonio. The ore occurs over wide areas as float and also in small veins and lenses. The ore thus far shipped is an oxide said to carry less than 0.5 per cent of other metals. Car lots averaged 46 to 52 per cent antimony. The ore was hauled by wagons 90 miles to Santa Ana, the nearest railroad point, and from there shipped to the smelter of the Western Metals Co., at Harbor City, near Los Angeles, Calif. The maximum monthly capacity of the mine is said to be about 400 tons of ore. Shipments during the year were much delayed because of the uncertain political and market conditions. Freight charges from Santa Ana to Harbor City were $8.75 a ton, and Mexican export duties and charges aggregated about $5 a ton.

BOLIVIA.

According to the United States Bureau of Foreign and Domestic Commerce,[3] the exports of antimony ore from Bolivia in 1917 were valued at $6,630,000, as against $6,591,000 in 1916.

FRANCE.

The following statement in regard to the French antimony industry is quoted from the American Metal Market and Daily Iron and Steel Report for July 8, 1918:

> The Société des mines de La Lucette et Le Genest, in France, is practically the only works in that country producing antimony on a considerable scale and has been showing considerable activity for some time past in extending its operations both at home and abroad. As regards refinery operations, it has been largely dependent upon oxide ores imported from Algeria, but developments at the La Lucette mine, which was originally worked unsuccessfully as a gold proposition, has resulted in the discovery that the entire area carries veins of stibnite interspersed with small gold-bearing stringers. This, it is thought, may have important effects upon the company's activities, in so far as French ore supplies are concerned, for the company is in a very good position to make use of gold-bearing stibnite. By means of the imported oxide ores the La Lucette Co. is able to produce about 300 tons a month of regulus of antimony and has thus been the mainstay of France so far as this particular metal is concerned during a very critical period.

AUSTRALIA.

According to the United States consul at Sydney,[4] the value of antimony ores exported from Australia for the fiscal years ending June 30, 1916 and 1917, was $530,410 and $378,808, respectively.

---

[1] Letter from William Dingwall, May, 1918.
[2] Letter from C. N. Miller, May 4, 1918.
[3] Commerce Repts., Oct. 24, 1918, p. 328.
[4] Supplement to Commerce Repts., No. 60b, Nov. 8, 1918, p. 5.

MANGANESE AND MANGANIFEROUS ORES.

By D. F. Hewett.

INTRODUCTION.

As manganese ore is one of the few mineral commodities for the supply of which the United States is largely dependent on foreign countries, the events of the war, particularly their effect upon marine trade, continued to determine the trend of the domestic industry. The production of steel from American furnaces had risen from 32,151,036 tons in 1915 to 42,773,680 tons in 1916, and the entry of the United States into the war in April, 1917, made it clear that the best efforts of the country would be given to maintain the maximum rate of production of iron and steel. As a result of these efforts, the production of steel for the year rose to 45,060,607 tons, and as small quantities of manganese alloys are essential in making almost all steel, there was a similar increase in the demand for manganese ores.

As it was widely thought and stated that the domestic supply of manganese ores was inadequate to meet increasing needs, it was natural that efforts should be made by consumers to procure as much foreign material as could be obtained under existing shipping conditions. Imports for the year rose, therefore, to the maximum record of 629,972 tons, of which 80 per cent came from Brazil. The hazard of moving materials through the submarine zone around Great Britain, which had been the source of nearly half this country's supply of manganese in the form of ferromanganese, reduced the imports of that alloy to 41,969 tons, the lowest since 1904. The increase in price of manganese alloys and ores caused by the shortage induced many persons to search for and exploit domestic deposits of the ores. The shipments of high-grade manganese ore during 1917 rose to 129,405 tons, or more than four times those of 1916 (31,474 tons). Likewise the shipments of low-grade material rose from 544,326 tons in 1916 to 860,944 tons in 1917.

The realization that the war might continue several years and that during a part of that period the submarine menace might greatly curtail the imports of raw materials led the United States Geological Survey, in cooperation with several State organizations, to make a careful survey of the location and extent of domestic manganese deposits and the classes of material they were capable of yielding. A similar study had been made by Harder[1] in 1909, but since then many new deposits had been discovered and the well-known districts had been further explored. Field work was begun in April, 1917, and the most important districts were examined during the summer. Although plans provided for continuing and practically completing this work during 1918, the work of the season of 1917 yielded data which permitted estimates of the probable production during 1918 that were nearly twice the actual production during 1917. It was therefore apparent early in the year that the domestic contribution of high-grade as well as low-grade ore would be an appreciable part of the country's needs.

---

[1] Harder, E. C., Manganese deposits of the United States, with sections on foreign deposits, chemistry, and uses: U. S. Geol. Survey Bull. 427, 1910.

The important geologic conclusions arising out of the field work were published as soon as possible after the work was finished.[1]

Manganese alloys and ore produced in the United States and imported from important foreign sources, 1890–1917, in gross tons.

Year.	Steel.	Ferromanganese.		Spiegeleisen.		Manganese ore.				
	Production.	Production.	Imports.	Production.	Imports.	Production.	Total imports.	Imports from—		
								Russia.	India.	Brazil.
1890	4,277,071	....	....	....	....	19,287	34,154	....	....	....
1891	3,904,240	....	....	....	....	22,452	28,825	....	....	....
1892	4,927,581	....	....	....	....	13,613	58,572	....	....	....
1893	4,019,995	....	....	....	....	7,718	68,113	[a] 36,070	(b)	....
1894	4,412,032	....	....	....	....	6,308	44,655	[a] 28,300	....	(c)
1895	6,114,834	....	....	....	....	9,547	86,111	[a] 55,987	....	....
1896	5,281,689	....	....	....	....	10,088	31,489	[a] 3,600	....	....
1897	7,156,957	....	....	....	....	11,108	119,961	38,910	17,400	12,083
1898	8,932,857	....	....	....	....	15,957	114,885	46,396	5,944	17,031
1899	10,639,857	....	....	....	....	9,935	188,349	73,397	17,950	28,115
1900	10,188,329	(d)	(e)	(d)	(e)	11,771	256,252	132,121	10,650	54,451
1901	13,473,595	59,639	20,750	231,822	26,827	11,995	165,722	32,600	11,000	48,029
1902	14,947,250	44,526	50,388	168,408	68,813	7,477	235,576	3,338	64,170	102,550
1903	14,534,978	35,961	41,519	156,700	122,015	2,825	146,056	5,576	35,960	76,910
1904	13,859,887	57,076	21,813	162,370	4,623	3,146	108,519	11,959	10,200	66,875
1905	20,023,947	62,186	52,841	227,797	55,457	4,118	257,033	24,650	101,030	114,670
1906	23,398,136	55,520	84,359	244,980	103,268	6,921	221,260	13,805	154,180	30,260
1907	23,362,594	55,918	87,400	283,430	48,994	5,604	209,021	1,000	95,300	52,922
1908	14,023,247	40,642	44,624	111,376	4,579	6,144	178,203	250	143,813	17,150
1909	23,955,021	82,209	88,934	142,831	16,921	1,544	212,765	14,486	145,140	35,600
1910	26,094,919	71,376	114,228	153,055	25,383	[f] 2,258	242,348	33,120	140,965	53,750
1911	23,676,106	[f] 74,602	80,263	[f] 104,013	20,970	[f] 2,457	176,852	19,103	103,580	41,600
1912	31,251,303	[f] 125,378	99,137	[f] 102,561	1,015	[f] 1,664	300,661	83,334	128,645	81,580
1913	31,300,874	[f] 119,495	128,070	[f] 106,980	77	[f] 4,048	345,090	124,337	141,587	70,200
1914	23,513,030	[f] 100,731	82,997	[f] 76,625	2,870	[f] 2,635	283,294	52,681	103,583	113,924
1915	32,151,036	[f] 144,260	55,263	[f] 114,556	200	[f] 9,613	320,778	....	36,450	275,579
1916	42,773,680	[f] 224,103	90,928	[f] 182,837	....	[f] 31,474	576,321	....	51,960	471,837
1917	45,060,607	[f] 260,225	41,969	[f] 189,241	3,968	[f] 129,405	629,972	....	48,975	512,517

[a] Drake, Frank, The manganese ore industry of the Caucasus: Am. Inst. Min. Eng. Trans., vol. 28, p. 191, 1898.

[b] First shipment made from India.

[c] First shipments made from Brazil.

[d] Figures for ferromanganese and spiegeleisen combined prior to 1901.

[e] Figures for fiscal years only available prior to 1901.

[f] Marketed production.

SOURCES OF MANGANESE.

MANGANESE MINERALS.

Though manganese forms a part of about one hundred minerals and is a relatively widespread element, practically all the manganese in commercial use is derived from material containing one or more of the first seven of the minerals named in the following table:

---

[1] For brief summaries, refer to the discussion by States (pp. 682–686); also to bibliography (pp. 691–696).

Principal manganese minerals.

Mineral	Composition.	Percentage of manganese.
Pollanite	MnO_2	63.2
Pyrolusite	$MnO_2.nH_2O$	60-63
Psilomelane	$MnO_2.(MnKBa)O.nH_2O$	45-60
Wad	Hydrous impure mixture of manganese oxides	5-50
Manganite	$Mn_2O_3.H_2O$	62.4
Braunite	$3Mn_2O_3.MnO.SiO_2$	69
Franklinite	$(FeZnMn)O.(FeMn)_2O_3$	10-19
Rhodochrosite	$MnO.CO_2$	47.56
Rhodonite (manganese pyroxene)	$MnO.SiO_2$	41.9
Tephroite (manganese olivine)	$2MnO.SiO_2$	54.3
Spessartite (manganese garnet)	$3MnO.Al_2O_3.3SiO_2$	33.3

MANGANESE ORES.

In the report on manganese ores in 1916[1] a new classification of the manganese-bearing raw materials of the United States was adopted. It was the purpose of the new classification to group the raw materials according to manganese content so that the quantities of material capable of certain specific uses would be indicated. Thus, in restricting the term "manganese ore" to material containing more than 40 per cent of manganese it was the intention to indicate that practically all material in this class was capable of being smelted to ferromanganese containing 80 per cent of manganese, the product which is made from a large part of such ore. The war brought about changes in practice in the making and use of manganese alloys, so that early in 1918 it seemed desirable to change the limits previously placed in the classification of the ores. The action that led to this change was the recommendation in April, 1918, by the American Iron and Steel Institute to its members, who include the officials of practically every steel company in the United States, that ferromanganese containing 70 per cent of manganese be used as far as practicable in place of the 80 per cent alloy and that spiegeleisen containing 16 per cent of manganese be used in place of 20 per cent alloy, and therefore that alloys of the lower grades be accepted on contracts for the higher grades. The purpose of lowering the grade of ferromanganese from 80 to 70 per cent of manganese was to permit the wider use of domestic ores in making the alloy. Actually, the grade of alloy which may be made from an ore depends largely upon the percentages of manganese, iron, and silica that are present. If a classification were to indicate truly the use to which the material could be put, it should properly be based upon assigned limits to each of these ingredients. In the United States, however, there are few large deposits of manganiferous materials of any grade which appear to be capable of shipping regularly over long periods material exhibiting the narrow ranges in composition that much foreign material shows. The actual work required in classifying the shipments from individual mines according to a system based upon the percentages of manganese, iron, and silica is too great to permit the ready adoption of such a system by the domestic producers. In spite of certain obvious objections, therefore, the adopted classification is based upon the manganese content alone.

---

[1] Hewett, D. F., U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 733-734, 1918.

The new classification aims to group materials that are capable of being used to make the grades of alloys adopted as a war expedient. It remains to be determined whether the steel industry will continue to make and use the new grades of alloys or whether when the supply of high-grade foreign ores is not hindered the industry will demand the old grades. Probably many steel makers will return to the use of the old grades of alloys, but as some makers appear to be satisfied with new grades, it will serve a purpose to continue the classification of ore adopted during the war.

Material containing more than 35 per cent of manganese will be considered manganese ore. If the manganese in such material is present as one of the common oxides, it is possible for other substance to make up about 45 per cent of the total. On the other hand, if the manganese is present as carbonate, only 27 per cent of other substances may be present. During 1917 large quantities of oxide material were marketed from Arizona, California, and Montana which contained more than 16 per cent of silica, and some mines reported shipments with as much as 27 per cent of silica. The iron content of manganese ores from most of the States is low—generally from 2 to 5 per cent—but material from several districts, especially Bisbee, Ariz., and Lake Valley, N. Mex., ranges from 3 to 11 per cent, and the average is close to 9 per cent. The average composition of the entire output during 1917—129,405 tons—as reported by the shippers, was manganese, about 42.5 per cent; iron, 2.8 per cent; silica, 14 per cent; natural basis, but moisture not reported.

Material containing 10 to 35 per cent of manganese will be considered ferruginous manganese ore. In the report for 1916 the range for material under this class was 15 to 40 per cent of manganese. It should be stated that there is no natural basis for choosing the percentage that marks the distinction between manganese ore and ferruginous manganese ore. Any such percentage must be arbitrarily chosen on the basis of the use to which the material is to be put. Although large quantities of both oxide and carbonate materials containing from 35 to 40 per cent of manganese were shipped from a number of States during 1917, relatively little material containing 25 to 35 per cent of manganese has been produced from domestic deposits. Most of the material that is classified as ferruginous manganese ore, produced largely in Minnesota, Michigan, Nevada, and Colorado, contains from 14 to 25 per cent of manganese, 25 to 35 per cent of iron, and 8 to 20 per cent of silica.

The objection has been made that in some districts such material has long been known as manganiferous iron ore and that it will be confusing to restrict the name to material containing 5 to 10 per cent of manganese which was not widely mined and used until recently, and to apply a new name to material that was formerly known by the old name. In reply to this objection it may be stated that there is need for two terms and that the material containing more than 10 per cent of manganese has more interest and commonly derives more value from its manganese than from its iron content. Spiegeleisen containing 16 per cent of manganese may be made from most of the material that is produced in the United States at present, although less than one-third was so used in 1917.

Material containing 5 to 10 per cent of manganese is classified as manganiferous iron ore. The market for such material lies mainly with the makers of basic pig iron, so called because it is especially adapted to making steel by the basic open-hearth process. There is no record that any of this material is used for making spiegeleisen.

Manganiferous silver ore is applied to those materials, either oxides or carbonates, that contain more than 5 per cent of manganese and sufficient silver to make them more valuable as a source of silver than of manganese. Such materials commonly contain from 5 to 45 per cent of iron, several per cent of silica and lead, and a little gold and copper, and are shipped to lead or copper smelters where the silver, gold, lead, and copper are recovered and the manganese aids in making a more fusible and fluid slag.

Manganiferous zinc residuum is a product that commonly contains 14 to 15 per cent of manganese and is obtained by roasting franklinite, a mineral found only in several deposits near Franklin Furnace, N. J.

MANGANESE AND MANGANIFEROUS ORES.

SHIPMENTS AND PRODUCTION.

Manganese and manganiferous ore shipped in 1915.

State.	Ore containing 35 per cent of manganese or more.			Ore containing 10 to 35 per cent of manganese.			Ore containing 5 to 10 per cent of manganese.		
	Number of shippers.	Quantity (gross tons).	Value.	Number of shippers.	Quantity (gross tons).	Value.	Number of shippers.	Quantity (gross tons).	Value.
Alabama	1	200	(a)						
Arizona:									
Used for fluxing				1	1,452	(a)			
Used for other purposes	1	339	(a)						
Arkansas	7	1,288	$13,135	3	2,655	$8,742			
California	6	2,563	29,004						
Colorado:									
Used for fluxing				13	10,799	16,946	8	[b]4,166	$2,656
Used for other purposes	1	150	(a)	4	15,956	41,527			
Georgia	4	3,168	33,927	1	676	(a)			
Minnesota				3	42,973	187,971			
Nevada:									
Used for fluxing				1	104,498	(a)			
Tennessee	1	150	(a)						
Texas	1	(a)	(a)						
Utah:									
Used for fluxing	1	55	(a)						
Used for other purposes	1	(a)	(a)						
Virginia	7	1,620	17,988	6	1,944	6,708			
Wisconsin							1	10,616	(a)
Undistributed		80	19,057			535,087			17,517
	31	9,613	113,111	32	180,953	796,981	9	[b]14,782	20,173

[a] Included under "Undistributed." Survey not at liberty to publish.

[b] Includes 796 gross tons of ore containing less than 5 per cent manganese.

Manganese and manganiferous ore shipped in 1916.

State.	Ore containing 35 per cent of manganese or more.			Ore containing 10 to 35 per cent of manganese.			Ore containing 5 to 10 per cent of manganese.		
	Number of shippers.	Quantity (gross tons).	Value.	Number of shippers.	Quantity (gross tons).	Value.	Number of shippers.	Quantity (gross tons).	Value.
Alabama	1	(a)	(a)						
Arizona:									
Used for fluxing				1	7,392	$39,904			
Used for other purposes	5	3,060	$113,060						
Arkansas	10	6,318	180,722	6	3,682	22,665			
California	6	6,136	122,592	1	139	(a)			
Colorado:									
Used for fluxing				15	7,405	17,986	10	[b] 8,858	$1,029
Used for other purposes	3	110	1,670	(c)	90,850	299,012			
Georgia	1	(a)	(a)	2	(a)	(a)			
Minnesota				5	193,257	685,875	3	47,146	104,887
Montana	6	6,418	37,978						
Nevada:									
Used for fluxing				1	122,429	(a)			
Used for other purposes	2	(a)	(a)						
New Mexico	1	(a)	(a)	2	16,068	(a)			
Pennsylvania				1	451	(a)			
Tennessee	3	429	8,380						
Texas	1	(a)	(a)						
Utah:									
Used for fluxing				1	(a)	(a)			
Used for other purposes	6	1,282	22,597	1	(a)	(a)			
Virginia	15	4,417	118,342	7	7,213	28,079	2	(a)	(a)
Washington	1	(a)	(a)	1	(a)	(a)			
Wisconsin							1	3,982	6,570
Undistributed		3,304	50,937		4,967	693,908		30,487	76,715
	61	31,474	656,278	[d] 44	453,853	1,787,429	16	[b] 90,473	189,201

---

[a] Included under "Undistributed." Survey not at liberty to publish.
[b] Includes 1,026 gross tons of ore containing less than 5 per cent manganese.
[c] Not ascertained.
[d] Number of shippers of ore in Colorado for purposes other than fluxing not ascertained; therefore, not included in this total.

Manganese and manganiferous ore shipped in 1917.

State.	Ore containing 35 per cent of manganese or more.			Ore containing 10 to 35 per cent of manganese.			Ore containing 5 to 10 per cent of manganese.		
	Number of shippers.	Quantity (gross tons).	Value.	Number of shippers.	Quantity (gross tons).	Value.	Number of shippers.	Quantity (gross tons).	Value.
Alabama	3	264	$10,588	......	....	....	......	....	....
Arizona:									
Used for fluxing	......	....	....	2	17,018	(a)	1	15,396	(a)
Used for other purposes	22	14,802	479,971	2	2,040	(a)	......	....	....
Arkansas	13	10,140	448,511	11	9,100	$83,227	......	....	....
California	40	14,196	328,501	4	152	1,760	......	....	....
Colorado:									
Used for fluxing	1	54	(a)	17	14,166	23,799	14	[b]6,380	$10,719
Used for other purposes	1	60	(a)	14	104,315	269,284	......	....	....
Georgia	13	3,614	89,888	10	13,281	118,368	......	....	....
Michigan	......	....	....	1	52,198	(a)	......	....	....
Minnesota	......	....	....	8	359,573	1,828,835	2	91,590	(a)
Montana	28	61,109	1,797,842	2	1,568	(a)	......	....	....
Nevada:									
Used for fluxing	......	....	....	1	122,872	142,543	......	....	....
Used for other purposes	6	3,450	91,907	......	....	....	......	....	....
New Mexico	6	2,603	54,143	1	15,900	(a)	......	....	....
North Carolina	2	102	(a)	......	....	....	......	....	....
South Carolina	1	405	(a)	1	650	(a)	......	....	....
Tennessee	13	1,996	75,066	2	83	(a)	......	....	....
Texas	1	25	(a)	1	135	(a)	......	....	....
Utah:									
Used for fluxing	......	....	....	1	100	(a)	......	....	....
Used for other purposes	6	4,195	118,927	1	36	(a)	......	....	....
Virginia	18	12,360	588,806	12	17,577	131,197	3	16,819	54,771
Wisconsin	......	....	....	......	....	....	[c]1	[c]200,327	(a)
Wyoming	1	30	(a)	......	....	....	......	....	....
Undistributed	......	....	25,622	......	....	439,279	......	....	602,083
	175	129,405	4,109,722	91	730,759	3,036,292	[c]20	[bc]130,185	[c]369,769

---

[a] Included under "Undistributed." Survey not at liberty to publish.

[b] Includes 141 gross tons of ore containing less than 5 per cent manganese.

[c] Manganiferous iron ore from Wisconsin, containing approximately 5 per cent of manganese, not included in totals.

Manganese and manganiferous ore produced in the United States, 1838 to 1917, in gross tons.[a]

Year.	Ore containing 35 per cent of manganese or more.	Ore containing 10 to 35 per cent of manganese.	Ore containing 5 to 10 per cent of manganese.	Year.	Ore containing 35 per cent of manganese or more.	Ore containing 10 to 35 per cent of manganese.	Ore containing 5 to 10 per cent of manganese.
1838-1879	43,860	....	....	1899	9,935	(b)	
1880	5,761	....	....	1900	11,771	(b)	
1881	4,895	....	....	1901	11,995	(b)	
1882	4,532	....	....	1902	7,477	(b)	
1883	6,155	....	....	1903	2,825	(b)	
1884	10,180	....	....	1904	3,146	(b)	
1885	23,258	(b)		1905	4,118	(b)	
1886	30,193	(b)		1906	6,921	41,300	
1887	34,524	(b)		1907	5,604	103,844	
1888	29,198	(b)		1908	6,144	55,894	
1889	24,197	(b)		1909	1,544	68,654	
1890	19,287	(b)		1910	2,258	41,260	19,841
1891	22,452	(b)		1911	2,457	37,584	6,853
1892	13,613	(b)		1912	1,664	40,863	10,654
1893	7,718	(b)		1913	4,048	51,512	7,891
1894	6,308	(b)		1914	2,635	91,666	6,599
1895	9,547	(b)		1915	9,613	180,953	[c]14,782
1896	10,088	(b)		1916	31,474	453,853	[d]90,473
1897	11,108	(b)		1917	129,405	730,759	[e]130,185
1898	15,957	(b)					
					587,865	....	....

[a] Beginning with 1910, the figures represent ore marketed (or shipments).

[b] Manganiferous ore included in iron ore figures.

[c] Includes 796 tons of ore containing less than 5 per cent of manganese.

[d] Includes 1,026 tons of ore containing less than 5 per cent of manganese.

[e] Includes 141 tons of ore containing less than 5 per cent of manganese.

MANGANESE ORE.

PRODUCTION.

The activity in the manganese ore industry during 1917 is shown by the great increase in the number of shippers, which rose from 61 to 175, and by a greater increase in shipments, which rose from 31,474 to 129,405 tons. Although the increase in the number of shippers was greatest in California, from 6 to 40, most of the shipments represent the results of a brief campaign of prospecting the deposits in that State, of which there are known to be many. Other States that showed great increases in the number of shippers include Arizona, Georgia, Montana, and Tennessee.

Shipments of ore showed the greatest increase in Montana, the 61,109 tons shipped during 1917 being the most thus far recorded in any State for one year. More than three-fourths of the total shipments for the year were derived from districts in States west of the eastern boundary of Colorado, and a large part of this quantity came from deposits that were not recorded before the war aroused interest in manganese deposits. Further, the shipments during 1917 from this region were more than six times those during 1916. By contrast, the shipments from the well-known eastern districts in Arkansas, Georgia, Tennessee, and Virginia, with which the name "manganese" has been particularly identified for many years, contributed scarcely one-fifth of the total shipments during 1917 and only two and one-half times those from the same districts during 1916. The explanation of this inability of the eastern districts to respond quickly to the increasing demand and higher prices appears to lie in the nature of the deposits rather than in their number and size. The material that is shipped from practically all the eastern deposits is the product of washing or concentration, and the output is therefore determined by the capacity of existing mills, and even though the mills are not complicated structures considerable time must elapse before the number can be greatly increased. On the other hand, with one exception, the western deposits yielded during 1917 material that was shipped with no more preparation than rough sorting.

The grade of the eastern material is rather better than that of the western. Although it is not possible to make an accurate calculation of the average composition of the shipments from each district in 1917, available data indicate that the eastern ores contain 2 or 3 per cent more manganese, 5 or 6 per cent less silica, and about 0.1 per cent more phosphorus than the western ores.

IMPORTS.

The following table was compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce:

Manganese ore imported into the United States, 1914–1917.

	1914		1915		1916		1917	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Argentina	....	....	....	....	....	....	6,600	$40,023
Australia	....	....	....	....	488	$19,313	....	....
Belgium	450	$5,913	....	....	....	....	....	....
Brazil	113,924	736,769	275,579	$2,240,837	471,837	7,139,821	512,517	8,578,296
British India	103,583	504,981	36,450	194,626	51,960	401,779	48,975	362,582
Canada	64	1,357	325	12,989	756	72,496	883	40,534
Chile	....	....	....	....		18	202	6,330
Costa Rica	....	....	....	....	1,244	38,703	7,163	211,601
Cuba	....	....	5,141	69,453	30,563	514,184	44,511	612,413
France	5	1,580	....	....	....	....	....	....
Germany	1,713	92,273	258	23,590	....	16	....	....
Greece	....	....	....	....	3,000	24,318	....	....
Japan	40	1,320	2,810	106,434	5,196	163,491	2,745	85,538
Mexico	....	....	....	....	390	7,093	345	9,790
Netherlands	2,505	52,213	50	1,792	....	....	....	....
Panama	....	....	....	....	10,498	265,772	5,202	163,120
Portugal	....	....	....	....	289	11,997	....	....
Russia	52,681	490,331	....	....	....	....	....	....
United Kingdom	8,321	136,206	49	4,730	100	7,178	805	152,084
All other	8	1,177	116	1,529	....	....	[a] 24	[a] 618
	283,294	2,024,120	320,778	2,655,980	576,321	8,666,179	629,972	10,262,929

[a] Includes 4 tons, valued at $180, from British South Africa and 20 tons, valued at $438, from China.

PRODUCTION IN PRINCIPAL PRODUCING COUNTRIES.

The following table gives the latest available statistics with regard to American and foreign production of manganese ore.

So far as possible the figures are taken from the official publication of the country concerned, which is the case with Canada, Belgium, France, German Empire, India, Italy, and Spain; otherwise, Mines and Quarries, London, is used. The Geological Survey receives assistance in its foreign statistics from Mineral Industry, New York.

Manganese ore produced in principal producing countries, 1913–1917, in gross tons.

Country.	Percentage of manganese.	1913	1914	1915	1916	1917
North America:						
Canada	(?)	....	25	180	855	131
Costa Rica	37–48	....	....	....	[a] 1,244	[a] 7,163
Cuba	36–44	....	....	[b] 9,000	[b] 33,120	[b] 41,651
Mexico	40+	....	....	....	[a] 390	[a] 345
Panama	50±	....	....	....	[a] 10,498	[a] 5,202
Porto Rico	40+	....	....	....	[a] 738	[a] 1,189
United States	35+	4,048	2,635	9,613	31,474	129,405
South America:						
Argentina	(?)	....	....	....	....	[a] 6,600
Brazil	38–50	120,368	180,738	284,111	495,172	524,436
Chile	40–48	....	....	....	....	[a] 202
Europe:						
Austria	(?)	16,280	(c)	(c)	(c)	(c)
Bosnia and Herzegovina	(?)	5,709	4,055	(c)	(c)	(c)
France	30+	7,610	(c)	(c)	(c)	(c)
Germany	30+	748	(c)	(c)	(c)	(c)
Greece	(?)	549	(c)	(c)	(c)	(c)
Hungary	(?)	18,706	(c)	(c)	(c)	(c)
Italy	18–45	1,596	1,623	12,379	17,960	(c)
Russia	41–48	1,289,370	[d] 703,762	[d] 8,705	[d] 8,722	(c)
Spain	29+	21,254	12,947	14,102	13,954	56,556
Sweden	(?)	3,938	3,585	7,487	3,585	(c)
United Kingdom	30+	5,393	3,437	4,640	5,140	9,942
Africa:						
Gold Coast	(?)	....	....	....	(e)	(c)
Tunis	(?)	....	....	1,437	1,995	5,708
Union of South Africa	(?)	....	....	....	....	123
Asia:						
India	47–52	815,047	682,898	450,416	654,204	590,813
Japan	50+	18,016	16,807	25,400	7,749	(c)
Oceania:						
Australia	40+	27	6	200	488	....

[a] Imports into United States. Production and exports not available.
[b] Figures collected by United States Geological Survey.
[c] Statistics not available.
[d] Exports.
[e] Shipments July, 1916, to November, 1917, 28,465 tons.

FERRUGINOUS MANGANESE ORES.

Although the number of shippers as well as the shipments of ferruginous manganese ore increased in most of the States during 1917, Minnesota and Michigan contributed three-fourths of the increase in total shipments. Several western districts, especially Leadville, Colo., and Silver City, N. Mex., were capable of greatly increased shipments, but their remoteness from the principal consuming centers of the Eastern States hindered marketing, and shipments from Leadville during 1917 were only 20 per cent more than in 1916, whereas shipments from Silver City were less than in 1916. All the shipments from Minnesota were derived from mines on the Cuyuna Range, and those from Michigan from the Bengal mine, Iron County.

Manganiferous silver ore shipped, 1907–1917, in gross tons.

Year.	Arizona.	Colorado.		Nevada.	Utah.
		For fluxing.	For other purposes.		
1907		32,197	67,514		
1908		35,581	15,973		
1909		52,119	12,905		
1910		55,770			
1911		41,753			
1912		48,618			
1913		49,753			
1914		37,781	2,100		
1915	[a] 1,452	14,965	15,956	104,498	55
1916	[a] 7,392	16,263	90,600	122,429	27
1917	[a] 32,009	20,546	104,169	122,872	100

[a] Ore containing more than 35 per cent of manganese sent to makers of manganese alloys not included.

Ferruginous manganese and manganiferous iron ores shipped from the Cuyuna district, Minn., 1913–1917, in gross tons.

Mine.	Ore containing 10 to 35 per cent of manganese.					Ore containing 5 to 10 per cent of manganese.					Total.
	1913	1914	1915	1916	1917	1913	1914	1915	1916	1917	
Algoma (Hoch)		192	7,600	23,000	[a] 84,125						[a] 114,917
Cuyuna Mille Lacs	[b] 26,200	55,000	35,221	90,000	112,554						318,975
Ferro				14,710	(a)						[a] 14,710
Hillcrest									2,712	9,590	12,302
Joan, Nos. 1 and 4					8,375						8,375
Mahnomen				(c)	4,000				[c] 43,000	82,000	129,000
Mangan, Nos. 1 and 2				30,329	52,290						82,619
Merritt, No. 1					33,180						33,180
Sultana			152	35,218	65,018						100,388
	26,200	55,192	42,973	193,257	359,542				45,712	91,590	814,466

[a] Shipments from Ferro mine included with Algoma mine for 1917. Not reported separately to the Geological Survey.
[b] Percentage of manganese not stated.
[c] Shipments from Mahnomen mine in 1916 averaged 5 to 14 per cent of manganese. Not reported in greater detail to the Geological Survey.

VALUE OF MANGANESE ORES.

In general the value of materials that contain manganese depends on the composition, the minerals present, and the condition or state of aggregation of the material. The value depends largely, of course, on the content of metallic manganese but incidentally on the absence of such substances as phosphorus, silica, copper, cobalt, and iron. For certain purposes, other things being equal, it depends on the amount of oxygen which will be liberated under certain conditions, and this is different for the several oxide minerals. If the material is to be used in the manufacture of manganese alloys in the blast furnace, it should be in coherent lumps, as fine sand and powder can not be treated to advantage. On the other hand, if the material is to be used to make dry batteries or flint glass and is not already in finely divided condition, it is crushed and pulverized.

The price offered for ore to be used to make ferromanganese is normally determined by the condition of the steel industry, and in the United States this price corresponds closely to that on the

English, French, Belgian, and German markets when allowance is made for the difference in freight rates between the mines and the place of delivery. This is true because the furnaces of these countries derive most of their ore from the same countries that supply the United States.

During 1917, however, several conditions brought about uncommon variations as well as disparities between the prices of ores and of alloys. The announcement of unrestricted submarine warfare in a zone surrounding Great Britain and France by Germany in February made the import of manganese ore to English furnaces and the export of ferromanganese exceedingly hazardous. As a result the price of ferromanganese rose rapidly, from $175 a ton in February to a maximum of $400 in July. This was followed by advances in the prices offered for ores. As shown in figure 12 (p. 681) during 1915 and 1916 the advance in the price of manganese ore followed rather slowly the advances in the price of ferromanganese. The extraordinary profit in smelting ferromanganese, in part indicated by the intervals elapsing between an advance in the price of ferromanganese and that in the price of ore, stimulated a number of new smelters in the United States to enter the field. Some of these depended solely on imported ore, but a few that were advantageously situated were led to compete for the existing supply of domestic ore, with the result that during 1917 the prices offered for domestic ore advanced rapidly, closely following advances in price of alloys, and the prices offered in several localities, notably Chicago, were appreciably higher than those in other parts of the country.

The schedule of prices announced by the Carnegie Steel Co. on May 2, 1917, is given below. These prices are about 20 cents a unit higher than those offered March 9, 1917, and 45 cents a unit higher than those offered August 25, 1916.

Schedules of prices paid per ton of 2,240 pounds for domestic manganese ore delivered at Pittsburgh, Etna, Pa., and South Chicago, Ill.

Prices are based on ores containing not more than 8 per cent silica or 0.20 per cent phosphorus and are subject to deductions as follows: For each 1 per cent in excess of 8 per cent silica there shall be a deduction of 15 cents per ton; fractions in proportion. For each 0.02 per cent, or fraction thereof, in excess of 0.20 per cent phosphorus there shall be a deduction of 2 cents per unit of manganese per ton; fractions in proportion.

Ores containing less than 40 per cent manganese or more than 12 per cent silica or 0.225 per cent phosphorus are subject to acceptance or refusal at the buyer's option.

Settlements are based on analysis of sample dried at 212° F., the percentage of moisture in the sample as taken being deducted from the weight.

Percentage of metallic manganese in ore.	Price per unit of manganese, in cents.
Over 49	100
46 to 49	98
43 to 46	95
40 to 43	90

According to these specifications the price paid for ores ranged from $36 for 40 per ore to $50 for 50 per cent ore. In the fall of 1917 this schedule was withdrawn, and subsequently purchases were based upon specific bids for each lot, or upon special contracts.

In July, 1917, the Miami Metals Co., Chicago, Ill., offered the following schedule of prices for ore purchased during that month:

For manganese ore of normal physical structure the following prices per gross ton (2240 pounds) f. o. b. Chicago:

	Cents per unit.
35 to 37 per cent	74
37 to 39 per cent	80
39 to 41 per cent	86
41 to 43 per cent	92
43 to 45 per cent	96
45 to 47 per cent	100
47 to 49 per cent	104
49 per cent or more	108

There will be a penalty of 50 cents per ton for each per cent of silica over 10 per cent, and a bonus of 50 cents per ton for each per cent of silica under 10 per cent, also a penalty of 15 cents a ton for each 0.01 per cent phosphorus over 0.15 per cent. Material with more than 20 per cent silica and 0.25 per cent phosphorus will be subject to rejection.

In December, 1917, it was reported[1] that high-grade Indian ore had recently been sold for $1.30 per unit and similar Brazilian ore at $1.10 to $1.20 per unit, at seaboard. The following prices were also offered for domestic material by a dealer: 38 to 42 per cent of manganese, 90 cents per unit; 42 to 46 per cent, $1.00 per unit; 46 to 50 per cent, $1.10 per unit, and 50 per cent or more, $1.20 per unit.

The value of an ore adapted to use as an oxidizer in dry batteries and flint glass varies with its content of manganese dioxide and, in contradistinction to those used in metallurgic industries, does not depend, except indirectly, on its content of metallic manganese. As much of the ore of the Caucasus region, Russia, contains from 85 to 92 per cent of manganese dioxide and less than 1 per cent of iron and is therefore admirably adapted to these uses, most specifications for ores to be put to these uses before the war were such as could be met by ore from the Caucasus region but only rarely by ores from other regions. According to one manufacturer of dry batteries, as long as Caucasian ore was available there was little experimentation to determine the suitability of the several manganese minerals and the limits beyond which other elements than manganese may be present. As a result of recent experiments, it has been shown that copper, nickel, and cobalt are the most harmful elements in the ordinary dry battery and should not be present in even minute quantities. A few tenths of 1 per cent of any of these elements renders an ore unfit for this use. On the other hand, it is stated that 2 or 3 per cent of iron as oxide does not necessarily greatly affect the efficiency of a battery and that the 1 per cent limit is arbitrary. In the absence of an established schedule, such as exists in the steel industry, most of the ore is supplied to the dry-battery makers by brokers in lots ranging from 5 to 100 tons under guaranteed specifications. On account of the temporary elimination of Caucasian ore prices have risen, and it is reported that during 1917 prices ranged from $75 to $160 a ton. Few of the known deposits of the United States are capable of producing more than a small quantity of ore that contains less than 1 per cent iron and a trace of copper, nickel, and cobalt. Early in 1917 ore containing no more than 70 per cent of manganese dioxide was marketable for these uses. It is estimated that the present demand for manganese ore for dry batteries and flint glass is about 25,000 tons a year.

---

[1] Iron Age, vol. 100, p. 1359, Dec. 6, 1917.

The value of ferruginous manganese ores, manganiferous iron ores, and manganiferous silver ores depends on local conditions in the metallurgic industries that consume them, as the manganese content is used only indirectly. In both Minnesota and Colorado it is customary to pay a flat rate for ore having a certain percentage of manganese, iron, silica, moisture, and phosphorus. For each additional per cent of manganese a premium is paid, and for each additional per cent of silica or mositure a penalty is charged.

Ferruginous manganese ores containing 15 to 35 per cent of manganese, less than 15 per cent of silica, and the remainder chiefly iron were sold at the mines in 1917 at prices that ranged from $4.50 to $18 a ton.

Manganiferous zinc residuum is not sold in the open market but is smelted to spiegeleisen by the only company that produces it.

MANGANIFEROUS ZINC RESIDUUM.

Unique deposits of zinc ore containing franklinite, willemite, zincite, calcite, and minor silicate and other minerals occur near Franklin Furnace, N. J. By mechanical and electromagnetic processes of separation three products are obtained from these ores, one containing the greater part of the franklinite and the remaining two the other zinc minerals. The franklinite product is first roasted with anthracite to eliminate the zinc, which is recovered as zinc oxide, and the residue, containing from 14 to 15 per cent of manganese and 40 per cent of iron, is smelted to spiegeleisen, containing 19 to 20 per cent of manganese.

Manganiferous residuum produced from zinc roasting in the United States, 1889–1917.

	Gross tons.		Gross tons.		Gross tons
1889	43,648	1900	87,110	1910	137,173
1890	48,560	1901	52,311	1911	109,296
1891	38,228	1902	65,246	1912	104,670
1892	31,859	1903	73,264	1913	102,239
1893	37,512	1904	68,189	1914	100,198
1894	26,981	1905	90,289	1915	159,318
1895	43,249	1906	93,461	1916	198,817
1896	44,953	1907	93,413	1917	155,332
1897	33,924	1908	110,225		
1898	48,502	1909	141,264		2,404,241
1899	65,010				

NOTE.—The manufacture of spiegeleisen from manganiferous residuum was begun in 1870, but there is no record of the quantity of raw material used prior to 1889.

FERROMANGANESE AND SPIEGELEISEN.

In 1917 the number of plants engaged in making ferromanganese increased to 23, and the marketed output of the alloy increased to 260,225 tons, the highest on record. At the same time the imports of ferromanganese declined to 41,969 tons, the lowest since 1904. The available supply of ferromanganese was therefore 302,194 tons.

The number of plants engaged in making spiegeleisen also increased to 17 in 1917, and the marketed output was 189,241 tons. This, with the 3,968 tons imported indicates an available supply of 193,209 tons for the year.

A list of the plants where ferromanganese and spiegeleisen were made in 1917 follows (f indicates ferromanganese; s, spiegeleisen):

s American Manganese Manufacturing Co., Dunbar, Pa.
fs Berkshire Iron Works, Sheridan, Pa.
fs Bethlehem Steel Co., Lebanon, Pa.
f Bethlehem Steel Co., Sparrows Point, Md.
f Bilrowe Alloys Co., Tacoma, Wash.
s Colorado Fuel & Iron Co., Pueblo, Colo.
f Donner Steel Co., Tonawanda, N. Y.
s T. B. Guernsey & Co. (Inc.), Graham, W. Va.
fs Juniata Furnace & Foundry Co., Newport, Pa.
f Lackawanna Iron & Steel Co., Lebanon, Pa.
fs E. J. Lavino & Co., Marietta, Pa.
fs Lebanon Blast Furnace Co., Labanon, Pa.
f E. E. Marshall, Harrisburg, Pa.
fs Miami Metals Co., South Chicago, Ill.
s New Jersey Zinc Co., Palmerton, Pa.
f Noble Electric Steel Co., Heroult, Calif.
fs Oriskany Ore & Iron Corporation, Reusens, Va.
fs Seaboard Steel & Manganese Corporation, Temple, Pa.
f Seattle Smelting Co., Seattle, Wash.
fs Southeastern Iron Corporation, Goshen, Va.
fs Southern Manganese Corporation, Anniston, Ala.
fs Tennessee Coal, Iron & Railroad Co., Bessemer and Birmingham, Ala.
fs United States Steel Corporation, Chicago, Ill., and Pittsburgh, Pa.
f Western Reduction Co., Portland, Oreg.
f Wharton Steel Co., Wharton, N. J.

Ferromanganese and spiegeleisen produced[a] *in the United States, 1901–1917.*

Year.	Ferromanganese.		Spiegeleisen.	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
1901	59,639	(b)	231,822	(b)
1902	44,526	(b)	168,408	(b)
1903	35,961	(b)	156,700	(b)
1904	57,076	(b)	162,370	(b)
1905	62,186	(b)	227,797	(b)
1906	55,520	(b)	244,980	(b)
1907	55,918	(b)	283,430	(b)
1908	40,642	(b)	111,376	(b)
1909	82,209	(b)	142,831	(b)
1910	71,376	(b)	153,055	(b)
1911	74,602	[c]$4,746,541	104,013	(c)
1912	125,378	[c]8,282,006	102,561	(c)
1913	119,495	[c]9,272,269	106,980	(c)
1914	100,731	4,440,253	76,625	$1,586,139
1915	144,260	9,253,443	114,556	2,403,550
1916	224,103	30,123,493	182,837	6,158,202
1917	260,225	53,930,771	189,241	9,756,236

[a] Beginning with 1911 the figures represent product marketed (or shipped).
[b] Figures not available.
[c] Value for spiegeleisen included with that for ferromanganese.

Ferromanganese and spiegeleisen imported for consumption in the United States, 1903–1917.

Year.	Ferromanganese.		Spiegeleisen.		Total.	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
1903	41,519	$1,699,666	122,015	$2,709,317	163,534	$4,408,983
1904	21,813	707,037	4,623	132,461	26,436	839,498
1905	52,841	1,884,651	55,457	1,336,104	108,298	3,220,755
1906	84,359	4,953,644	103,268	2,942,940	187,627	7,896,584
1907	87,400	5,354,656	48,994	1,399,381	136,394	6,754,037
1908	44,624	1,860,664	4,579	125,054	49,203	1,985,718
1909	88,934	3,396,381	16,921	356,447	105,855	3,752,828
1910	114,228	4,341,071	25,383	489,049	139,611	4,830,120
1911	80,263	3,015,062	20,970	405,444	101,233	3,420,506
1912	99,137	3,906,920	1,015	28,094	100,152	3,935,014
1913	128,070	5,682,915	77	2,173	128,147	5,685,088
1914	82,997	3,619,607	2,870	71,147	85,867	3,690,754
1915	55,263	3,333,699	200	5,110	55,463	3,338,809
1916	90,928	9,240,528	....	....	90,928	9,240,528
1917	41,969	5,710,988	3,968	291,594	45,937	6,002,582
	1,114,345	58,707,489	410,340	10,294,315	1,524,685	69,001,804

Ferromanganese and spiegeleisen are essentially alloys of manganese, iron, and carbon, although in the ordinary process of manufacture it is impossible to prevent the presence of small quantities of silicon and phosphorus. Their use depends upon the effects produced by the addition of small quantities of manganese and carbon to molten steel. It is commonly stated that a part of the manganese combines with any oxygen in the molten steel, that the remainder increases the tensile strength of the steel, and that the carbon raises the percentage of that element to the desired proportion. The name spiegeleisen (German, mirror iron) was given on account of the highly brilliant plates that develop when the alloy with 15 to 20 per cent of manganese crystallizes. It commonly contains manganese, 20 per cent; iron, 75 per cent; and carbon, 5 per cent. The ratio of manganese to carbon is therefore 4 to 1. Ferromanganese commonly contains manganese, 78 to 82 per cent; iron, 12 per cent; and carbon, 7 per cent. The ratio of manganese to carbon is therefore about 12 to 1. There appears to be no natural division between the manganese content of spiegeleisen and ferromanganese, but 40 per cent is commonly accepted by the steel trade.

Spiegeleisen was the first alloy to be developed, and it was added to all steel made by the Bessemer and open-hearth processes until about 1875, when ferromanganese became a commercial product. For many years thereafter spiegeleisen was used only in making so-called "medium" and "high-carbon" steels (those containing more than 0.25 per cent of carbon) by the Bessemer process, whereas ferromanganese was used in making "low-carbon" steel (that containing less than 0.25 per cent of carbon). It can readily be understood that for a given quantity of manganese in the form of alloys added to the molten steel, three times as much carbon is added if spiegeleisen is used as if ferromanganese is used. During recent years many makers of steel have experimented with the use of alloys having a manganese content intermediate between that in spiegeleisen and that in ferromanganese, as well as with other alloys, such as silicomanganese. The use of several of the alloys for special purposes has been fairly established, and although a few makers of steel have contended that in spite of the low ratio of manganese to carbon alloys containing 15 to 35 per cent of manganese could be used to make steel containing 0.10 to 0.25 per cent of carbon the practice has not come into wide use.

The foregoing summary is given to show that although a certain quantity of manganese is apparently needed in making steel by the Bessemer and open-hearth processes, the quantity of each alloy that is needed appears to depend largely on the desired carbon content of the steel that is made but possibly may be slightly changed by local experimentation. So far as the writer is aware, there are no accurate statistical data available concerning the carbon content of different varieties of steel made in the United States and the manganese alloys used in making them. The following table has been prepared on the assumption that only ferromanganese has been used recently in making open-hearth steel and that only spiegeleisen has been used in making Bessemer steel. Even though this assumption is not

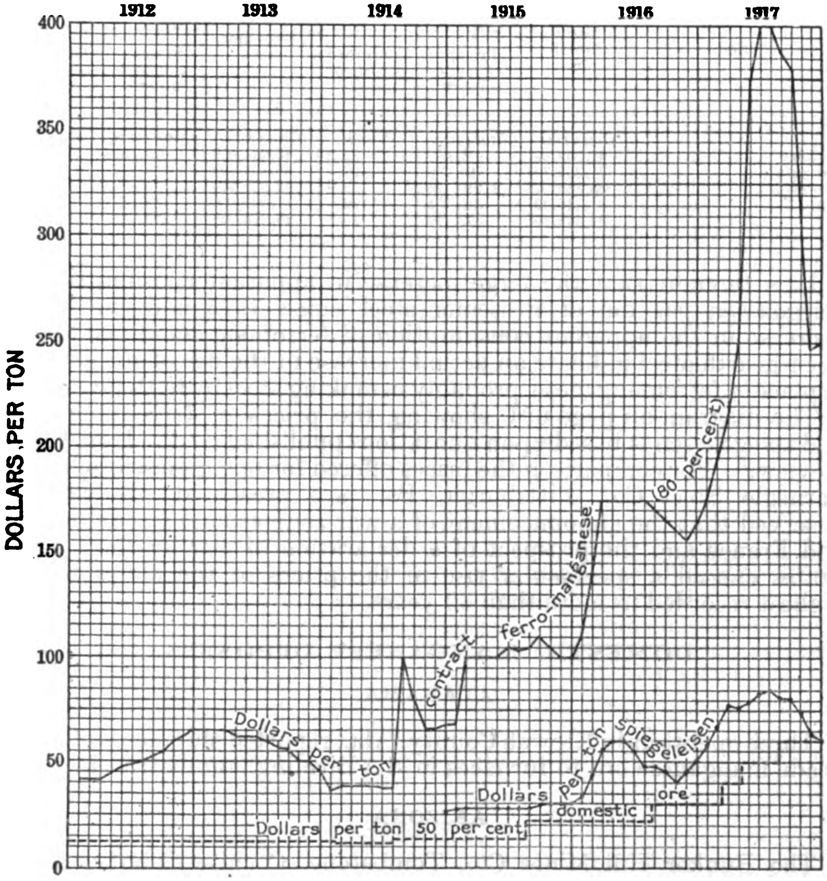


FIGURE 12.—Diagram showing contract prices of feromanganese, spegeleisen, and manganese ore, 1912-1917.

strictly true, it probably yields dependable conclusions with regard to the consumption of manganese alloys. The table disregards the small quantities of alloys exported and the difference between stocks at the beginning and end of each year.

Apparent domestic consumption of ferromanganese and spiegeleisen per ton of steel, 1901–1917.

Period.	Open-hearth steel.	Ferromanganese.		Bessemer steel.	Spiegeleisen.	
		Production and imports.	Consumed per ton of steel.		Production and imports.	Consumed per ton of steel.
	Gross tons.	*Gross tons.*	*Pounds.*	*Gross tons.*	*Gross toms.*	*Pounds.*
1901–1905	31,053,491	446,699	32.2	45,245,009	1,224,832	60.6
1906–1910	61,365,323	725,210	26.5	48,803,689	1,134,817	52.1
1911–1915	98,833,090	1,010,196	22.9	42,329,520	529,867	28.0
1916	31,415,427	315,031	22.5	11,059,039	182,837	37.0
1917	34,148,893	302,194	19.8	10,479,960	193,209	41.3

It is thought that the large increase in apparent consumption of spiegeleisen per ton of Bessemer steel since 1915 and the slight decrease in the apparent consumption of ferromanganese per ton of open-hearth steel indicate an actual increase in the use of spiegeleisen in place of ferromanganese, probably in making steel by both processes.

The diagram on page 681 showing the prices of ferromanganese and spiegeleisen is based upon quotations published by the Iron Trade Review.[1] For comparison the prices offered for manganese ore by the Carnegie Steel Co., Pittsburgh, Pa., are presented. It will be observed that the announcement of a war zone around Great Britain and France and the prospect of a declaration of war by the United States caused a spectacular rise in the prices of the alloys to the highest recorded in more than 30 years.

DOMESTIC MANGANESE DEPOSITS.

ALABAMA.

Three operators in Etowah County, Ala., reported shipments of high-grade manganese ore to furnaces in the Birmingham district in 1917.

ARIZONA.

The Bunker Hill Mines Co., Tombstone, Cochise County, Ariz., continued to produce ore, a part of which was shipped raw, and a part was treated in concentrating mills before shipping. The principal source of production in Arizona, however, was the Bisbee district, Cochise County, where the Calumet & Arizona Mining Co. and Thomas Higgins maintained regular shipments from several properties.

There was much prospecting in several other counties, notably in the Aguila district, Maricopa County, as well as in Mohave, Yavapai, Pinal, Gila, Greenlee, and Santa Cruz counties. E. L. Jones, jr., examined a number of these deposits in 1917, and a preliminary report based on his work was issued as a press bulletin. A more detailed report is in preparation.

---

[1] Iron Trade Review, vol. 62, p. 25, 1918.

ARKANSAS.

With the exception of several small shipments from Pike County, in western Arkansas, the output of manganese in Arkansas in 1917 came from the Batesville district in Independence and Izard counties, where there was much more activity than in 1916. Although only a few deposits in the district yielded more than several hundred tons of high-grade product, the great number that are opened and the ease with which they may be exploited permit the aggregate output to compare favorably with that of other States.

CALIFORNIA.

Manganese deposits are widespread throughout California, and in 1917 shipments were reported from 57 deposits in 21 counties. The Ladd deposit, in San Joaquin County, contributed the largest quantity, but shipments from the Tolbard mine, Imperial County, and the Braito mine, Plumas County, were also noteworthy. The counties in which there was the greatest activity, as measured by number of shipping mines, were in order, Mendocino, Alameda, Santa Clara, Plumas, Imperial, San Bernardino, San Joaquin, followed by 14 others.

Although many deposits have long been known in the first four counties, as well as others, the deposits of Imperial and San Bernardino counties that yielded considerable ore were not discovered until 1916 and 1917, when the shortage of manganese ore in the United States aroused interest in prospecting.

COLORADO.

Although there were a few attempts to mine and ship high-grade manganese ore in several counties in Colorado, including Fremont and Custer, interest in manganese in this State is particularly attached to the deposits of the Leadville district. Of 124,915 tons shipped from the district in 1917, 104,315 tons was shipped to makers of manganese alloys, and for the first time the material was sent to furnaces at Chicago, Ill., and Pittsburgh and Temple, Pa.

Umpleby[1] examined the low-grade deposits of the Leadville and Red Cliff districts in August, 1917.

GEORGIA.

Almost the entire output of manganese ore from Georgia during 1917 came from mines of the Cartersville district, Bartow County, but several deposits in Fannin, Haralson, Murray, and Paulding counties also contributed. The largest shipments came from several deposits operated by the Georgia Iron & Coal Co.

MICHIGAN.

The Bengal mine, in Iron County, Mich., continued to ship during 1917 material which contained manganese, 16.83 per cent; iron, 37.01 per cent; and silica, 5.48 per cent (dry basis).

---

[1] Umpleby, J. B., Leadville manganese resources: Min. and Sci. Press, vol. 115, p. 758, 1917; Manganiferous iron ore occurrences at Red Cliff, Colo.: Eng. and Min. Jour., vol. 104, p. 1140, 1917.

MINNESOTA.[1]

When the shortage of ferromanganese and high-grade ore became serious late in 1917, the larger market for spiegeleisen and low-grade ore created a greater demand for the ores of the Cuyuna range, Minn., than had been known before. The district underwent further intensive exploration, and several new mines, including the Joan Nos. 1 and 4 and Merritt No. 1, capable of shipping material containing 15 to 30 per cent of manganese, were brought to the producing stage.

MISSOURI.

Explorations in the vicinity of Cornwall, Madison County, Mo.,[2] yielded about 100 tons of material containing 40 per cent of manganese, 5 per cent of iron, and 15 per cent of silica.

MONTANA.

The active search for and exploration of manganese deposits in the Philipsburg district, Mont., begun in 1916, continued throughout 1917. In comparison with the four operators who shipped 6,380 tons from six deposits in 1916, 19 operators shipped 59,327 tons of material containing more than 35 per cent of manganese from 27 deposits in 1917. Early in 1917 it was widely recognized that the district contained the largest deposits of readily available high-grade material in the United States. The deposits were examined and described by Umpleby.[3]

It has long been known that the surficial zone of many silver and zinc-bearing lodes of the Butte district contained oxides of manganese and that the deeper zone contained rhodochrosite, carbonate of manganese, and rhodonite, silicate of manganese. Although oxidized ores had been mined as a source of silver from time to time, the first efforts were made in 1917 to mine and ship these materials as a source of manganese. The oxidized zones of several lodes, especially the Ancient, yielded small quantities of oxides, but large bodies of rhodochrosite were developed in the Emma mine, and the first shipments, containing manganese, 38.1 per cent; iron, 1.8 per cent, and silica, 6.2 per cent were made. The deposits have been described by Pardee.[4]

Other deposits near Cherry and Wigwam creeks,[5] near Renova, Madison County,[5] and near Melrose, Beaverhead County, were explored during 1917.

NEVADA.

There was a widespread search for manganese deposits in Nevada in 1917, and a number of new deposits were reported. The most noteworthy was that of the Three Kids mine, 14 miles west of Las Vegas, Clark County, although others were reported in Humboldt and White Pine counties. Shipments were made from the Three

---

[1] Harder, E. C., and Johnston, A. W., Notes on the geology of the iron ores of the Cuyuna district, Minn.; U. S. Geol. Survey Bull. 660, pp. 1-26, 1917. Harder, E. C., Manganiferous iron ores of the Cuyuna district, Minn.: Am. Inst. Min. Eng. Trans., vol. 58, pp. 453-484, 1918.

[2] Reported by G. L. Barnes, Cornwall, Mo.

[3] Umpleby, J. B., The manganese deposits of Philipsburg, Mont.: Min. and Sci. Press, vol. 115, p. 725, 1917.

[4] Pardee, J. T., Manganese at Butte, Mont.: U. S. Geol. Survey Bull. 690, pp. 111-130, 1918.

[5] Pardee, J. T., Some manganese deposits in Madison County, Mont.: U. S. Geol. Survey Bull. 690, pp. 131-143, 1918.

Kids deposit, as well as from those near Shafter, Elko County, and near Ely, White Pine County, previously recorded. The Prince Consolidated Mining & Smelting Co. continued to ship silver-bearing low-grade ore from its mines near Pioche.[1]

NEW MEXICO.

The Lake Valley mine, near Lake Valley, Sierra County, N. Mex., yielded a large part of the shipments of high-grade manganese ore from New Mexico during 1917. A new deposit near Water Canyon, Socorro County, also yielded considerable ore, a representative carload of which contained manganese 42.34 per cent; iron, 1.20 per cent; silica, 9.48 per cent; phosphorus, 0.027 per cent; water, 19.04 per cent. Other deposits near Rincon, Dona Ana County, and near Silver City, Grant County, shipped high-grade ore.

The low-grade deposits near Silver City[2] yielded approximately the same quantity of material as in 1916.

SOUTH CAROLINA.

Shipments of manganese ore from South Carolina in 1917 were derived from the deposits near McCormick, Abbeville County, operated by the Atlantic Mining Co.

TENNESSEE.

The manganese deposits of Tennessee attracted considerable interest during 1917, and the number of areas within which deposits are known to exist was greatly increased. Shipments were made from deposits in Bradley, Carter, Cocke, Johnson, and Loudon counties.

TEXAS.

High-grade manganese ore was shipped from the Spiller mine in Mason County, Tex., and trial shipments of low-grade material were made from recently discovered deposits near Shumla, Val Verde County.[3]

UTAH.

Several groups of claims in the Little Grand district, Grand County, Utah, were the source of regular shipments of high-grade manganese ore in 1917. Similar material was shipped from several deposits in the Tintic district, Juab and Tooele counties, and near Marysvale, Piute County.

VIRGINIA.

The great increase in the quantity of high-grade manganese ore shipped from Virginia in 1917, as compared with 1916, is due largely to the discovery and exploitation of the Miller mine, near Suiter, Bland County, which stimulated great interest in prospecting for manganese in Bland and adjoining counties.

---

[1] Umpleby, J. B., Manganese fluxing ore at Pioche, Nev.: Eng. and Min. Jour., vol. 104, p. 760, 1917.

[2] Umpleby, J. B., Manganiferous iron deposits at Silver City, N. Mex.: Eng. and Min. Jour., vol. 104, p. 921, 1917.

[3] Umpleby, J. B., Some western manganese deposits (preliminary report): U. S. Geol. Survey press bulletin, 1917.

The Kennedy mine, near Stuarts Draft; and the Crimora mine, near Crimora, Augusta County; several new deposits opened by the United States Manganese Co., near Elkton, Rockingham County; and the Powell Fort mine of the Stockwood Realty Co., Shenandoah County, shipped regularly throughout the year. A number of old deposits were reopened in many parts of the State.

Systematic studies of the manganese deposits of the Valley of Virginia were undertaken by the United States Geological Survey in cooperation with the Virginia Geological Survey. On the basis of this work, a preliminary report[1] was issued in which the location and features of six tracts which have not been exploited but which appear to contain deposits of manganese are set forth.

WYOMING.

A recently discovered deposit of manganese ore 38 miles northeast of Medicine Bow, Albany County, Wyo., was the source of a shipment of uncommonly high-grade material adapted to use in dry batteries.

FOREIGN MANGANESE DEPOSITS.

AFRICA.

GOLD COAST COLONY, WEST AFRICA.

S. H. Ford[2] describes some manganese deposits that were discovered by A. E. Kitson, a Government geologist, in 1914, at Dagwin, near Taquah. As the material was greatly needed in England, the deposits were vigorously explored and a spur from the Seccondle Railway, 200 yards distant, was built. From June, 1916, to November 7, 1917, 28,465 tons of high-grade material was shipped. The rocks near by are deeply weathered, and the associations of the manganese minerals are obscure.

TUNIS.

According to Consul E. C. Kemp,[3] 5,800 tons (metric?) of manganese ore was produced in Tunis in 1917. The exact source of the material is not stated.

ASIA.

SOUTHERN CHINA.

Consul General George E. Anderson[4] states that the conditions under which metallic minerals are sampled and purchased in southern China are not conducive to maximum production. He says that managanese ore is purchased but does not give the source of the material.

---

[1] Hewett, D. F., Stose, G. W., Katz, F. J., and Miser, H. D., Possibilities for manganese in certain undeveloped tracts in Shenandoah Valley, Va.: U. S. Geol. Survey Bull. 660, pp. 271–296, 1918.

[2] Ford, S. H., Manganese in West Africa; Min. Mag., vol. 17, p. 271, 1917.

[3] Commerce Reports, Apr. 16, 1918.

[4] Idem, June 22, 1917.

INDIA.

Consul Lucien Memminger[1] submits a statement showing the cost of mining and transporting manganese ore derived from the surface laterite deposits in the Shimoga district, State of Mysore, India. The cost of mining, transportation to the port of Marmagoa, and port charges is 26 rupees, 10 annas ($8.60) a ton.

The Iron Age[2] presents a table showing the analyses of a number of cargoes of Indian manganese ore received in the United States in 1915, 1916, and 1917. Twenty-three cargoes received in 1917 showed the following range in composition: Manganese, 50.0 to 53.1 per cent; silica, 4.98 to 7.97 per cent; phosphorus, 0.063 to 0.114 per cent; moisture, 0.335 to 1.265 per cent.

RUSSIA.[3]

According to the British consul at Batum there was a remarkable revival in the Caucasus manganese industry in 1916. The Russian [iron] works, which formerly drew most of their supplies from the Nikopol mines in south Russia, were unable to obtain sufficient ore from that source in 1916, and therefore supplies from the Caucasus deposits were in greater demand. During the 10 years preceding the war these works obtained, through the ports of Poti and Mariupol, an annual average quantity of about 2,000,000 poods [32,770 metric tons]. In 1916, however, their demands amounted to 12,000,000 poods [196,618 metric tons]. The actual quantity of ore dispatched from Tchiaturi during 1916 was 15,755,250 poods [258,146 metric tons], of which 9,650,750 poods [158,125 metric tons] were sent inland by rail via Baku and the remainder went to Poti. Of the latter quantity rather less than half was for shipment by the Black Sea route to south Russia; the remainer was added to the stocks that were in Poti at the outbreak of hostilities with Turkey and that at the end of 1916 amounted to nearly 8,000,000 poods [131,076 metric tons]. According to official figures the stock of ore at Tchiaturi at the end of 1916 was 45,000,000 poods [737,302 metric tons], and 3,000,000 poods [49,153 metric tons] was calculated to be in stock at Batum. Thus the total stock of manganese ore in the Caucasus at the end of 1916 was 56,000,000 poods [917,532 metric tons], and it would therefore appear that the production of ore in 1916 more than kept pace with the demand from the Russian market.

Notwithstanding the fact that the existing washing plants at Tchiaturi are capable of producing 45,000,000 poods [737,302 metric tons] of washed ore and that the installation of new plants at present is costly, preparations for an extension of washing plants were proceeded with during the year and several new ones were installed.

A large number of exploration certificates were issued by the Mining Department of the Caucasus in 1916 for prospecting work on petroliferous plots in many parts of Transcaucasia and the northern Caucasus, and also for similar work on manganese ore bearing lands in the district of Sharopan in the Government of Kutais.

SOUTH AMERICA.

BRAZIL.

Consul General A. L. M. Gottschalk[4] reports the exports of manganese ore from Brazil during the first six months of each year from 1913 to 1917. Later[5] he reports the monthly shipment of manganese ore over the Central Railroad of Brazil from the mines to Rio de Janeiro. The table follows:

---

[1] Idem, Dec. 28, 1917.

[2] Iron Age, vol. 101, p. 287, 1918.

[3] Quoted from British Board of Trade Jour., July 19, 1918. Reprinted in Commerce Reports, Aug. 8, 1917.

[4] Commerce Repts., Dec. 11, 1917.

[5] Idem, Dec. 26, 1917.

Manganese ore shipped over Central Railroad of Brazil to Rio de Janeiro, 1914–1917, in tons.

Month.	1914	1915	1916	1917
January	26,468	26,735	36,025	39,843
February	17,510	22,915	32,780	37,505
March	20,510	24,587	31,441	40,700
April	16,172	24,690	34,675	46,659
May	21,058	25,138	29,400	38,747
June	26,785	20,295	37,040	51,037
July	22,720	19,060	40,394	39,158
August	14,960	21,100	40,639	58,758
September	12,450	28,330	36,338	45,059
October	21,075	30,370	40,099	60,188
November	19,620	30,635	35,940	....
December	25,857	36,025	37,654	....
	245,185	309,880	432,425	457,654

He also reports [1] that an American company has recently purchased four mines in the State of Bahia, the largest in the municipality of Bom-Fim, northwest of Bahia, but not well explored. Three other deposits are near the town of Nazareth, southwest of Bahia. The rate of shipment from these deposits is hindered by lack of railway facilities.

Ambassador E. V. Morgan,[2] at Rio de Janeiro, reports that the State of Minas Geraes has increased the existing export duty on manganese ore. The duty includes an ad valorem tax as well as a special tax, also based on the value. The first duty ranges from 4 per cent where the official valuation is less than 40 milreis per ton to 8 per cent where it is more than 50 milreis per ton. The special tax ranges from 1 to 3 francs per metric ton in addition for similar grades. On the basis of the proposed valuation of 120 milreis per ton, these duties equal 11.700 milreis or about $3 per metric ton.

Consul A. L. M. Gottschalk reports [3] the following destination of exports of manganese ore from Brazil in 1914, 1915, and 1916:

Manganese ore exported from Brazil, 1914, 1915, and 1916.

	1914		1915		1916	
	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.
United States	87,630	$713,380	266,871	$2,457,488	503,120	$7,080,809
Great Britain	23,500	154,248	10,100	73,192	....	....
Belgium	10,600	69,575	....	....	....	....
France	11,400	74,836	....	....	....	....
Other countries	50,500	268,414	11,700	101,747	10	145
	183,630	1,280,453	288,671	2,632,427	503,130	7,080,954

---

[1] Idem, July 21, 1917, p. 262.

[2] Idem, Nov. 3, 1917.

[3] Idem, Dec. 27, 1917.

COSTA RICA.

Yonge[1] describes the recently exploited manganese deposits on the Nicoya Peninsula, Guanacaste Province, Costa Rica. The deposits have been known for several years, but the inaccessibility of the region and the climate prevented systematic explorations until 1916. Oxides of manganese are widespread, and float is found in many stream beds, but existing explorations do not permit detailed descriptions of the associations of the deposits.

The ore is mined from surface openings, is carried by a system of tramways to two temporary piers, loaded on large lighters, and towed to steamers in the open roadstead. Rules for the maintenance of healthy conditions in a camp in a malarial region are given in detail.

Consul B. F. Chase,[2] of San Jose, Costa Rica, reports that between 300 and 400 men are engaged in mining manganese ore in Guanacaste. Deposits are found in many parts of Guanacaste. Exports of ore from Costa Rica in 1916 were 1,305 tons, and in 1917, 8,191 tons.

CUBA.

Consul H. M. Walcott[3] makes the following report concerning the manganese mining situation in eastern Cuba:

> While several hundred manganese mining claims have been filed during the past year at the mining bureau of this Province, in only a small number has it been demonstrated that they may be operated at a profit, even with the present abnormally high prices paid for the ore. The lack of proper transportation facilities and of good roads is the great drawback to the development of the industry here. With three exceptions the mines have to haul their ore to the railroad in ox carts and mule carts, or by pack mules, for a distance of 3 to 15 miles, and at a cost of $3.50 to $10 a ton.
>
> As most of the ores are of low grade and practically none come up to the standard of 48 per cent metallic manganese, it is difficult to operate at a profit under the conditions that exist. The roads that are available during the few months of the dry season become practically impassable in the season of abundant rainfall which usually occurs from April to November. Some of the American mine operators are now introducing motor trucks and tractors for transportation of the ore, and it is hoped that by this means some of the present difficulties may be overcome.
>
> The manganese mines or claims of this Province may be divided into nine groups—Cristo, Ponupo, San Nicolas, Palmarito, Los Negros, Santa Rita, Guisa, Sabanilla, and South Coast—the most important of which are the Ponupo and Cristo.
>
> The Ponupo group produces at present about 5,000 tons of ore a month. It is chiefly low grade, averaging from 38 to 40 per cent metallic manganese, and is rather low in silica and iron. As this group is near the line of the railroad, the ore is mined and shipped at a profit under present prices.
>
> The Cristo group consists of several small claims which at present produce approximately 4,000 tons of ore monthly. The mineral runs slightly higher in metallic manganese and about the same in silica and iron as the Ponupo ore, but the greater part of it requires washing.
>
> The Palmarito and Los Negros groups produce each about 1,000 tons monthly. The ore from them is high grade and very low in silica and iron.
>
> Considerable modern machinery has recently been installed at the San Nicolas mines, and it is expected that several thousand tons monthly will soon be produced from this group.
>
> The remaining four groups have a combined monthly production at present estimated at 1,000 tons, making the total for the Province approximately 12,000 tons monthly, all of which is exported to the United States through the ports of Santiago and Nipe.
>
> The declared exports of manganese ore from the Province of Oriente in 1917 were valued at $567,849, of which a large proportion was shipped through the port of Santiago de Cuba, and the remainder from Antilla (Nipe).

---

[1] Yonge, A. M., Manganese deposits in Costa Rica: Eng. and Min. Jour., vol. 104, pp. 739–741, 1917.
[2] Commerce Repts., Nov. 19, 1918.
[3] Idem, Mar. 26, 1918, p. 1146.

HONDURAS.

Consul W. F. Boyle, Puerto Cortes, Honduras, reports [1] that residents of that district advise him that they have discovered a deposit of manganese ore within 2 miles of the Honduras National Railroad. It is stated that graphite, gold, and silver accompany the manganese.

PORTO RICO.

According to George Troutmann,[2] of Ponce, Porto Rico, manganese deposits were exploited during 1917 and 1918 near the town of Juana Diaz, 14 miles east of Ponce. Here manganese oxides occur in pockets in weathered marble, but their extent can not be determined in advance of mining. The analysis of a representative shipment of 2,000 sacks follows: Manganese dioxide, 86.52 per cent (manganese 56.75 per cent); iron, 0.34 per cent; copper, 0.10 per cent; sulphur, 0.04 per cent; phosphorus, 0.037 per cent; silica, 2.26 per cent; moisture, 5.53 per cent. The deposits occur at an elevation of about 950 feet, and the product is carried by pack animals 2 miles to a good wagon road by which the distance to Ponce is 12 miles.

The collector of customs of San Juan reports that 738 long tons of manganese ore was shipped from the island in 1916 and 1,189 long tons in 1917.

OCEANIA.

NEW ZEALAND.

Consul General A. A. Winslow, of Auckland, New Zealand, has forwarded [3] to the Bureau of Foreign and Domestic Commerce at Washington, correspondence with P. E. Cheal, of Cameron Road, Remuera, Auckland, in which a manganese deposit in the Otau district is described. The deposit lies 3 miles from Otau, and 35 miles south of Auckland, but if the deposit were to be exploited, it would be best to construct a tramway to Hauraki Gulf. The deposit appears to be a vertical lode, at least 10 feet thick, which crops out conspicuously along a ridge 1,400 feet above sea level. It is estimated that 16,000 to 18,000 tons of unusually high-grade material may be readily mined above the lowest workings, 76 feet below the outcrop.

UNION OF SOUTH AFRICA.

A. B. Welch [4] describes manganese deposits at seven localities in South Africa that lie at distances of 12 to 150 miles from Cape Town. Two of the three most valuable deposits are lodes of oxides in sandstone that range from 3 to 8 feet in width and are estimated to contain respectively about 2,000 and 8,000 tons of material that carries more than 35 per cent of manganese. The third deposit covers an area of about 600 by 900 feet on the crest of a hill of sandstone, from which a hot spring issues. Explorations show that in this deposit manganese oxides persist to a depth of at least 20 feet and indicate that 500,000 tons of material containing 30 per cent of manganese and 18 per cent of iron may be present. The origin of this deposit is obscure.

---

[1] Commerce Repts., Aug. 28, 1918.

[2] Letter dated Apr. 7, 1918.

[3] Letter dated Mar. 6, 1917.

[4] Manganese deposits of the southwest districts of the Cape Province, 10 pp., Dept. Mines and Industries, 1917.

BIBLIOGRAPHY OF MANGANESE DEPOSITS.

The following bibliography includes most of the authoritative and comprehensive reports that describe manganese deposits in the United States, as well as most foreign countries. It can not be considered complete. In preparing it the aim has been to present such references as would permit one who wished to become familiar with the present state of knowledge concerning manganese deposits, as well as their distribution, to do so in the minimum length of time. This scope necessarily eliminates many short articles that are essentially progress reports concerning a single mine or minor district as well as a few reports that are not readily accessible.

GENERAL.

Beyschlag, F., Krusch, P., and Vogt, J. H. L., Die Lagerstätten der nutzbaren Mineralien und Gesteine, 3 vols., 1910.

Demoret, L., Les principaux gisements des minérais de manganèse du monde: Annales des mines de Belgique, pp. 809–901, 1905.

Emmons, W. H., The principles of economic geology, pp. 508–511, 1918.

Fach, E., Le minéral de manganèse, 44 pp. Paris, H. Dunod & E. Pinat, 1914.

Fermer, L. L., The manganese deposits of India: India Geol. Survey Mem., vol. 37, 4 parts, 1909.

Harder, E. C., Manganese deposits of the United States; U. S. Geol. Survey Bull. 427, 1910.

Lindgren, Waldemar, Mineral deposits, pp. 251–253, 315–321, 1913.

Penrose, R. A. F., jr., Manganese, its uses, ores, and deposits: Arkansas Geol. Survey Ann. Rept. for 1890, vol. 1, 1893.

Stelzner, A. W., and Bergeat, A., Die Erzlagerstätten, 1904–1906.

NORTH AMERICA.

CANADA.

NEWFOUNDLAND.

Dale, N. C., Manganese deposits of Conception and Trinity bays (Newfoundland): Geol. Soc. America Bull., vol. 25, pp. 73–74, 1914.

——— The Cambrian manganese deposits of Conception and Trinity bays (Newfoundland): Am. Philos. Soc. Proc., vol. 54, pp. 371–456, 1915.

NOVA SCOTIA.

Kramm, H. E., The occurrence of manganese at New Ross, Nova Scotia: Canadian Min. Jour., vol. 33, p. 660, 1913.

UNITED STATES.

ALABAMA.

Gibson, A. M., Report on the structure of the Murphrees Valley, Ala.: Alabama Geol. Survey Rept., 1893, pp. 112–119.

ARIZONA.

Allen, M. A., and Butler, G. M., Manganese: Arizona Bur. Mines Bull. 91, pp. 32, 1918.

Jones, E. L., Jr., Some manganese deposits in western Arizona (preliminary report): U. S. Geol. Survey press bulletin, 1917.

ARKANSAS.

Joslin, G. A., Manganese in west-central Arkansas: Min. and Sci. Press, vol. 113, pp. 947–948, 1916.

Miser, H. D., Manganese deposits of the Caddo Gap and De Queen quadrangles, Ark.: U. S. Geol. Survey Bull. 660, pp. 59–122, 1917.

Penrose, R. A. F., jr., Manganese, its uses, ores, and deposits: Arkansas Geol. Survey Ann. Rept. for 1890, vol. 1, 1893.

CALIFORNIA.

Dolbear, S. H., The Ladd manganese mine: Min. and Sci. Press, vol. 110, p. 258, 1915.

——— The manganese industry in California: Min. and Sci. Press, vol. 110, p. 172, 1915.

——— Manganese and chromium in California: California State Min. Bur. Bull. 76, pp. 9–100, 1918.

COLORADO.

Argall, P., Siderite and sulphides in Leadville ore deposits: Min. and Sci. Press, vol. 104, pp. 50–54, 128–134, 1914.

Emmons, S. F., Geology and mining industry of Leadville, Lake County, Colo.: U. S. Geol. Survey Second Ann. Rept., pp. 201–290, 1882.

Emmons, S. F., and **Irving**, J. D., The Downtown district of Leadville, Colo.: U. S. Geol Survey Bull. 320, p. 21, 1907.

Means, A. H., Geology and ore deposits of Red Cliff, Colo.: Econ. Geology, vol. 10, pp. 1–27, 1915.

Umpleby, J. B., Leadville manganese resources: Min. and Sci. Press, vol. 115, p. 758, 1917.

——— Manganiferous iron ore occurrences at Red Cliff, Colo.: Eng. and Min.Trans., vol. 104, pp. 1140–1141, 1917.

GEORGIA.

Brewer, W. M., The manganese ores of Georgia: Alabama Indust. and Sci. Soc. Proc., vol. 4, pt. 2, p. 72, 1894.

Hayes, C. W., Manganese ores of the Cartersville district, Ga.: U. S. Geol. Survey Bull. 213, p. 232, 1903.

LaForge, **Laurence**, Manganese ore in the Cartersville district, Ga. (preliminary report): U. S. Geol. Survey press bulletin, 1918.

Watson, T. L., Geological relations of the manganese ore deposits of Georgia: Am. Inst. Min. Eng. Trans., vol. 34, p. 207, 1904.

——— Preliminary report on the manganese deposits of Georgia: Georgia Geol. Survey Bull. 14, 1908.

KANSAS.

Whitaker, W. A., and **Twenhofel**, W. H., Manganese in the Dakota sandstone of central Kansas: Econ. Geology, vol. 12, pp. 473–475, 1917.

MARYLAND.

Hewett, D. F., Some manganese deposits in Virginia and Maryland: U. S. Geol. Survey Bull. 640, pp. 37–71, 1916.

Singewald, J. T., jr., Manganese in Maryland: Maryland Geol. Survey, vol. 9, pp. 325–327, 1911.

MINNESOTA.

Harder, E. C., Notes on the geology and iron ores of the Cuyuna district, Minn.: U. S. Geol. Survey Bull. 660, p. 1–26, 1917.

——— Manganiferous iron ores of the Cuyuna district, Minn.: Am. Inst. Min. Eng. Bull., September, 1917, pp. 1313–1344.

McCarthy, E. P., Manganiferous iron ores of the Cuyuna range: Eng. and Min. Jour., vol. 100, p. 400–402, 1915.

Newton, E., Manganiferous iron ores of the Cuyuna district, Minn.: Minneapolis School of Mines Exper. Sta. Bull. 95, pp. 1–126, 1918.

Van Hise, C. R., and **Leith**, C. K., The geology of the Lake Superior region: U. S. Geol. Survey Mon. 52, pp. 211–216, 488, 604–605, 1911.

MONTANA.

Emmons, W. H., and **Calkins**, F. C., Geology and ore deposits of the Philipsburg quadrangle, Mont.: U. S. Geol. Survey Prof. Paper 78, pp. 209–212, 1913.

Pardee, J. T., Manganese at Butte, Mont.: U. S. Geol. Survey Bull. 690, pp. 111–130, 1918.

——— Some manganese deposits in Madison County, Mont.: U. S. Geol. Survey Bull. 690, p. 131–143, 1918.

Umpleby, J. B., The manganese deposits of Philipsburg, Mont.: Min. and Sci. Press, vol. 115, p. 725, 1917.

Weed, W. H., Geology and ore deposits of the Butte district, Mont.: U. S. Geol. Survey Prof. Paper 74, pp. 69, 79, 1912.

NEVADA.

Hale, F. A., jr., Manganese deposits of Clark County, Nev.: Eng. and Min. Jour., vol. 105, pp. 775–777, 1918.

Penrose, R. A. F., jr., A Pleistocene manganese deposit near Golconda, Nev.: Jour. Geology, vol. 1, p. 275, 1893.

Umpleby, J. B., Manganese fluxing ore at Pioche, Nev.: Eng. and Min. Jour., vol. 104, p. 760, 1917.

NEW JERSEY.

Spencer, A. C., U. S. Geol. Survey Geol. Atlas, Franklin Furnace folio (No. 161), p. 24, 1908.

Wolff, J. E., Zinc and manganese deposits of Franklin Furnace, N. J.: U. S. Geol. Survey Bull. 213, p. 214, 1903.

NEW MEXICO.

Umpleby, J. B., Manganiferous iron deposits at Silver City, N. Mex.: Eng. and Min. Jour., vol 104, p. 931, 1917.

Wells, E. H., Manganese in New Mexico: New Mexico State School of Mines Bull. 2, pp. 1-85, 1918.

NORTH CAROLINA.

Pratt, J. H., Manganese mining industry in North Carolina, 1905: North Carolina Geol. Survey Econ. Paper 6, pp. 29–32, 1902.

OKLAHOMA.

Hewett, D. F., Manganese and manganiferous ores in 1912: U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 219, 1913.

Reeds, C. A., Geology and mineral resources of the Arbuckle Mountains, Okla.: Oklahoma Geol. Survey Bull. 3, pp. 54–59, 1910.

OREGON.

Pardee, J. T., Manganiferous ore in Lake Creek district, Jackson County, Oreg. (preliminary report): U. S. Geol. Survey press bulletin, 1918.

SOUTH CAROLINA.

Hafer, C., Manganese in South Carolina: Eng. and Min. Jour., vol. 98, p. 1135, 1914.

Petre, R. W., Manganese in South Carolina: Eng. and Min. Jour., vol. 101, p. 1019, 1916.

TENNESSEE.

Nelson, W. A., A new manganese deposit in Tennessee: Resources of Tennessee; vol. 1, pp. 220–228, Tennessee Geol. Survey, 1911.

Purdue, A. H., Manganese deposits of Bradley County, Tenn.: Resources of Tennessee, vol. 8, pp. 46–47, Tennessee Geol. Survey, 1918.

Stose, G. W., and **Schrader, F. C.**, Manganese deposits of East Tennessee: Resources of Tennessee, vol. 8, pp. 153–207, 231–324, Tennessee Geol. Survey, 1918.

Watkins, J. H., Manganese in Tennessee: Eng. and Min. Jour., vol. 102, p. 545, 1916.

TEXAS.

Paige, Sidney, Mineral resources of the Llano-Burnet region, Tex.: U. S. Geol. Survey Bull. 450, pp. 82–83, 1911.

Roberts, J. R., and **Nash, J. P.**, The geology of Valverde County: Texas Univ. Bull. 1803, 1918.

UTAH.

Pardee, J. T., Manganese in the Green River district, Utah (preliminary report): U. S. Geol. Survey press bulletin, 1918.

——— Manganese ore in the Tintic district, Utah (preliminary report): U. S. Geol. Survey press bulletin, 1918.

VERMONT.

Jones, R. V., Manganese deposits of South Wallingford, Vt.: Eng. and Min. Jour., vol. 105, p. 779, 1918.

VIRGINIA.

Ball, S. M., Manganese deposits of Virginia: Eng. and Min. Jour., vol. 87, p. 1056, 1909.

Hall, C. E., Geological notes on the manganese ore deposits of Crimora, Va.: Am. Inst. Min. Eng. Trans., vol. 20, p. 46, 1892.

Hewett, D. F., Some manganese mines in Virginia and Maryland: U. S. Geol. Survey Bull. 640, pp. 37–71, 1916.

Hewett, D. F., **Stose**, G. W., **Katz**, F. J., and **Miser**, H. D., Possibilities for manganese ore in certain undeveloped tracts in Shenandoah Valley, Va.: U. S. Geol. Survey Bull. 660, pp. 271–296, 1918.

Judd, E. K., The Crimora manganese mine: Eng. and Min. Jour., vol. 83, p. 478, 1907.

Watson, T. L., Mineral resources of Virginia, pp. 235–258, Virginia-Jamestown Exposition Commission, 1907.

Anonymous, Mining of manganese ore in Virginia: Iron Age, vol. 97, p. 776, 1916.

WASHINGTON.

Jenkins, O. P., Two manganese deposits in northern Washington: Eng. and Min. Jour., vol. 105, p. 1082, 1918.

Pardee, J. T., Manganese in the Olympic region, Wash. (preliminary report): U. S. Geol. Survey press bulletin, 1918.

WYOMING.

Jones, E. L., jr., Manganese ore in Wyoming (preliminary report): U. S. Geol. Survey press bulletin, 1918.

MEXICO.

Biddle, C., Notes on Magdalena Bay, Mexico: Eng. and Min. Jour., vol. 82, p. 361, 1906.

Wallace, H. V., Deposits of manganese in Lower California: Min. and Eng. World, vol. 35, pp. 103–104, 1911; Min. and Sci. Press, vol. 103, pp. 201–202, 1911.

WEST INDIES AND CENTRAL AMERICA.

COSTA RICA.

Yonge, A. M., Manganese deposits in Costa Rica: Eng. and Min. Jour., vol. 104, pp. 739–741, 1917.

CUBA.

Brown, H. C., Mineral resources of Cuba in 1901, p. 24.

Hayes, C. W., **Vaughan**, T. W., and **Spencer**, A. C., A geological reconnaissance of Cuba, p. 62, 1901.

Souder, **Harrison**, Mineral deposits of Santiago, Cuba: Am. Inst. Min. Eng. Trans., vol. 35, p. 308, 1904.

Spencer, A. C., Manganese deposits of Santiago, Cuba: U. S. Geol. Survey Bull. 213, p. 251, 1903.

——— Manganese deposits of Santiago Province, Cuba: Eng. and Min. Jour., vol. 74, p. 247, 1902.

DOMINICAN REPUBLIC.

De Garston, E. M., Board of Trade Jour. (London), vol. 61, pp. 450–452, 1907.

PANAMA.

Chibias, E. J., Manganese deposits of the Department of Panama, Republic of Colombia: Am. Inst. Min. Eng. Trans., vol. 27, p. 63, 1897.

Williams, E. G., The manganese industry of the Department of Panama, Republic of Colombia: Am. Inst. Min. Eng. Trans., vol. 33, pp. 197–234, 1902.

ST. MARTIN.

Daily Cons. and Trade Reports, May 23, 1912.

SOUTH AMERICA.

BRAZIL.

Branner, J. C., The manganese deposits of Bahia and Minas, Brazil: Am. Inst. Min. Eng. Trans., vol. 29, p. 756, 1899.

Derby, O. A., On the manganese deposits of the Queluz (Lafayette) district, Minas Geraes: Am. Jour. Sci., 4th ser., vol. 12, p. 18, 1901.

——— On the original type of manganese ore deposits of the Queluz district, Brazil: Am. Jour. Sci., 4th ser., vol. 25, p. 213, 1908.

Frazer, R., Bahia, Brazil: Daily Cons. and Trade Reports., 1914, p. 476.

Harder, E. C., The geology of central Minas Geraes, Brazil: Jour. Geology, vol. 23, pp. 404–406, 1915.

——— Manganese ores of Russia, India, Brazil, and Chile: Am. Inst. Min. Eng. Trans., vol. 56, pp. 31–68, 1916.

Lustosa, Joaquin, and **Branner**, J. C., Manganese deposits of Morro da Mina, Brazil: Eng. and Min. Jour., vol. 86, pp. 496–497, 1908.

Scott, H. K., The manganese ores of Brazil: Iron and Steel Inst. Jour., vol. 1, p. 179, 1900.

Singewald, J. T., and **Miller**, B. L., Manganese ores of the Layette district, Minas Geraes, Brazil: Am. Inst. Min. Eng. Trans., vol. 56, pp. 7–30, 1916.

——— High-grade manganese ores of Brazil: Iron Age, vol. 97, p. 417, 1916.

CHILE.

Harder, E. C., Manganese ores of Russia, India, Brazil, and Chile: Am. Inst. Min. Eng. Trans., vol. 56, pp. 31–68, 1916.

EUROPE.

AUSTRIA.

Naske, T., Manganese ore in Austria: Stahl und Eisen, vol. 28, pp. 543–547, 1907.

Scott, H. K., Manganese ores of the Bukowina: Iron and Steel Inst. Jour., vol. 94, pp. 288–355, 1916.

BULGARIA.

Scott, H. K., Notes on some Bulgarian mineral deposits: Inst. Min. and Met. Bull. 103, 1913.

GERMANY.

Kern, J., Zur Frage der Mangan-versorgung Deutschlands: Bergwirtschaftliche Mitteilungen, Jahrg. 4, pp. 49–59, 1913.

Scheffer, ——, The importance of manganese and manganiferous ores in German industry: Glückauf, vol. 49, pp. 2056, 2111, 2151, 1913.

RUMANIA.

Butureanv, V. C., The ores of manganese and iron of the crystalline massif of Broskeni, Rumania: Soc. franç. min. Bull., vol. 40, pp. 164–177, 1917.

RUSSIA.

Drake, Frank, The manganese industry of the Caucasus: Am. Inst. Min. Eng. Trans., vol. 28, p. 191, 1898.

Cauldwell, F. W., Batum, Russia: Daily Cons. and Trade Reports, May 7, 1912.

De Hauptick, E., Russia in 1912: Min. Jour. (London), vol. 100, p. 6, 1912.

Scott, H. K., Discussion of paper by E. C. Harder: Am. Inst. Min. Eng. Trans., vol. 56, pp. 68–74, 1916.

SPAIN.

Hoyer, ——, Contributions to the knowledge of the manganese deposits of the Province of Huelva: Zeitschr. prakt. Geologie, vol. 19, pp. 407–438, 1911.

AFRICA.

BELGIAN CONGO.

Guillemain, C., On the knowledge of the ore deposits in the Province of Katanga, Belgian Congo Colony: Zeitschr. prakt. Geologie, vol. 21, p. 333, 1913.

TUNIS.

Manganese ore in Tunis: Iron and Steel Inst. Jour., vol. 3, p. 497, 1908 (quoted from Rassegna mineraria, vol. 28, pp. 233–236).

WEST AFRICA.

Ford, S. H., Manganese in West Africa: Min. Mag., vol. 17, p. 271, 1917.

ASIA.

BORNEO.

Manganese ore in Borneo: Iron and Steel Inst. Jour., vol. 3, p. 329, 1907. Abstracted from Board of Trade Jour., London, vol. 58, p. 228.

INDIA.

Fermor, L. L., The manganese deposits of India: India Geol. Survey Mem., vol. 37, pts. I, II, III, IV, 1909.

Carter, H. A., Manganese mining in British India: Min. and Sci. Press, vol. 103, pp.834–835, 1911.

Quinquennial review of the mineral production of India: India Geol. Survey Rec., vol. 46, pp. 135–139, 1915.

JAPAN.

Snodgrass, J. H., Manganese mining in Japan: Min. World, vol. 30, p. 790, 1909.

PHILIPPINES.

Smith, W. D., The asbestos and manganese deposits of Ilocos Norte: Philippine Jour. Sci., vol. 2, No. 3, p. 145, 1907.

Fanning, P. R., Manganese deposits of the Philippine Islands: Mineral Resources Philippine Islands, pp. 42–47, 1911.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN NEW MEXICO.[1]

(MINES REPORT.)

By Charles W. Henderson.

PRODUCTION.

The total value of the gold, silver, copper, lead, and zinc produced in New Mexico from ores and gravels in 1917 amounted to $34,896,936, as compared with $30,827,767 in 1916, an increase of $4,069,169, or 13 per cent. There were 192 producing mines, of which 177 were deep and 15 were placer, a decrease of 14 deep mines and of 4 placers. The output of gold was 51,478.64 fine ounces, valued at $1,064,158, a decrease of 15,398.83 fine ounces in quantity and of $318,322 in value. The output of silver was 1,394,365 fine ounces, valued at $1,148,957, a decrease of 371,909 fine ounces in quantity and of $13,251 in value. The output of copper was 105,568,000 pounds, an increase of 12,820,711 pounds; the output of lead (calculated as lead in lead bullion and lead in leaded zinc oxide) was 9,108,804 pounds, an increase of 894,615 pounds; and the output of zinc (calculated as spelter and as zinc in leaded zinc oxide) was 30,200,000 pounds, a decrease of 6,370,649 pounds.

Mine production of gold, silver, copper, lead, and zinc in New Mexico, 1904–1917.

Year.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	102,339	$381,930	214,553	4,972,170	3,122,872	13,493,835	$1,961,390
1905	145,629	317,510	369,192	6,126,025	1,510,209	15,142,254	2,460,535
1906	207,691	293,019	491,127	7,028,670	2,987,369	17,292,655	3,203,739
1907	219,992	329,982	705,544	10,990,015	3,809,881	750,085	3,239,823
1908	135,434	298,757	405,044	6,112,630	873,763	3,576,516	1,525,091
1909	164,156	239,491	397,783	5,393,146	5,029,767	13,085,945	2,070,368
1910	191,865	482,424	843,987	4,614,386	4,320,841	18,088,129	2,691,080
1911	232,699	762,808	1,354,540	4,057,040	2,966,222	10,237,176	2,704,843
1912	1,352,286	784,446	1,536,701	34,030,964	5,494,018	13,566,637	8,527,955
1913	2,217,660	881,926	1,631,273	56,308,706	3,946,304	16,523,161	11,694,002
1914	2,232,853	1,171,696	1,777,445	59,307,925	1,763,641	18,403,392	11,049,932
1915	2,797,072	1,461,105	2,005,531	76,788,366	4,542,361	25,404,064	19,279,468
1916	3,870,950	1,382,480	1,766,274	92,747,289	8,214,189	36,570,649	30,827,767
1917	4,576,827	1,064,158	1,394,365	105,568,000	9,108,804	30,200,000	34,896,936
Increase or decrease, 1917.	+705,877	−318,322	−371,909	+12,820,711	+894,615	−6,370,649	+4,069,169

[a] Includes placer production.

---

[1] For discussion of the geology of the districts mentioned in the following pages the reader is referred to the bibliography appended to the report for 1912 in Mineral Resources for 1912, pt. 1, p. 819, 1913; to U. S. Geol. Survey Bull. 507 (the mining districts of the western United States, by J. M. Hill, with a geologic introduction by Waldemar Lindgren), 1912; and to U. S. Geol. Survey Prof. Paper 68 (The ore deposits of New Mexico, by Waldemar Lindgren), 1910.

GOLD.

The gold produced from New Mexico ores and gravels in 1917 amounted to 51,478.64 fine ounces, valued at $1,064,158, as against 66,877.47 fine ounces, valued at $1,382,480, in 1916, a decrease of 15,398.83 fine ounces in quantity and of $318,322 in value. Colfax and Lincoln counties produced 17,268.67 fine ounces, valued at $356,975, or nearly 34 per cent of the total output of the State; Grant County produced 19,565.08 fine ounces, valued at $404,446, or 38 per cent; and Socorro County produced (chiefly from the siliceous mines at Mogollon) 12,616.49 fine ounces, valued at $260,806, or nearly 25 per cent of the total. Dry and siliceous ores yielded 39,496.71 ounces, valued at $816,469, or 77 per cent of the total. Copper ores contained 10,876.11 fine ounces, valued at $224,829, or 21 per cent of the total, chiefly from Central and Lordsburg districts, Grant County. Lead ores furnished 367.20 fine ounces, valued at $7,591, chiefly from the Victorio district, Luna County, and the Magdalena district, Socorro County. Coppper-lead ores furnished a small quantity of gold. The production of placer gold amounted to 589.16 fine ounces, valued at $12,179.

SILVER.

The silver produced from New Mexico ores and gravels in 1917 amounted to 1,394,365 fine ounces, valued at $1,148,957, as compared with 1,766,274 fine ounces, valued at $1,162,208, in 1916, a decrease of 371,909 fine ounces in quantity and of $13,251 in value. Of the total quantity Socorro County contributed 859,892 fine ounces, or 62 per cent, most of it from siliceous ore from the Mogollon district and the remainder from mixed ores of the Magdalena district. Grant County contributed 487,558 fine ounces, or 35 per cent of the total, chiefly from the Lordsburg district, though a considerable quantity came from the Central district. The output of silver from Grant and Socorro counties combined was 97 per cent of the total.

Dry and siliceous gold and silver ore, chiefly from Socorro and Grant counties, produced 966,006 fine ounces of silver, or 70 per cent of the total; copper ores chiefly from Grant and Socorro counties produced 315,877 ounces, or 23 per cent; lead ores, chiefly from the Central district, Grant County, the Victorio district, Luna County, and the Magdalena district, Socorro County, produced 70,021 ounces, or 5 per cent; copper-lead ores, chiefly from the Central district, Grant County, produced 29,600 ounces, or 2 per cent.

COPPER.

In 1917 the copper produced in New Mexico amounted to 105,568,000 pounds, valued at $28,820,064, an increase of 12,820,711 pounds and $6,004,231, as compared with the output in 1916. Grant County produced 101,373,641 pounds, or 96 per cent of the total, most of it the output of the Chino Copper Co., at Santa Rita, and of the Lordsburg and Burro Mountain districts. The increase for the year in Grant County was 13,589,096 pounds, which included an increase of 7,971,815 pounds in the Central district, and an increase of 6,245,026 in the Burro Mountain district. There was a decrease of 493,223 pounds in the Lordsburg district. The output of Otero County decreased 352,236 pounds and that of Santa Fe County decreased 1,753,467 pounds; but that of Socorro County increased 1,686,483 pounds.

Copper ores, chiefly from Grant, Otero, Santa Fe, Socorro, and Torrance counties, yielded 101,280,755 pounds, or 96 per cent of the total; dry and siliceous gold and silver ore, chiefly from the dry ore of Otero County and from the siliceous ore of Lordsburg district, Grant County, yielded 3,566,170 pounds, or 3 per cent; lead ores, chiefly from the Magdalena district, Socorro County, yielded 195,950 pounds; and copper-lead ores, chiefly from the Central district, Grant County, 482,372 pounds.

LEAD.

In 1917 the lead produced amounted to 9,108,804 pounds, valued at $783,357, an increase of 894,615 pounds in quantity and of $216,578 in value.

The principal lead-producing districts were the Central district, Grant County; the Magdalena district, Socorro County; the Cooks Peak and Victorio districts, Luna County. Socorro County produced 4,886,803 pounds; Grant County, 3,224,477 pounds; and Luna County, 721,177 pounds. Lead ores produced 5,635,818 pounds; zinc and lead-zinc ores, 2,479,132 pounds; and copper-lead ores, 690,320 pounds—the combined content of these classes of ores representing 97 per cent of the total.

ZINC.

The total zinc, whether marketed as spelter or as oxide, recoverable from crude ore and concentrates shipped from New Mexico in 1917, calculated in terms of spelter and zinc in the various forms of zinc oxide, was 30,200,000 pounds, valued (in terms of the Survey's average price of zinc for the year) at $3,080,400.

Mines producing zinc in New Mexico in 1917 were at Kelly, Socorro County; in the Central and Pinos Altos districts, Grant County; Cooks Peak, Florida Mountains, and Tres Hermanas districts, Luna County; and Cerillos district, Santa Fe County.

Zinc ore and concentrates marketed in New Mexico, 1916–17, and average assay of zinc.

Year.	Quantity.	Average assay.
	Short tons.	*Per cent.*
1916	74,944	29.16
1917	62,573	29.84
Decrease	12,371	

OUTPUT OF ORE AND METAL CONTENT.

Ore and metals produced in New Mexico in 1917.

Source.	Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Copper ore	4,188,027	10,876.11	315,877	101,280,755	92,673	
Dry ore	221,662	39,496.71	966,006	3,566,170	210,861	
Lead ore	17,426	367.20	70,021	195,950	5,635,818	
Lead-copper ore	3,684	88.74	29,600	482,372	690,320	
Zinc ore	135,129	.47	3,381	436	1,395,066	28,811,431
Lead-zinc	10,899	60.25	9,388	42,317	1,084,066	1,388,569
Total ores	4,576,827	50,889.48	1,394,273	105,568,000	9,108,804	30,200,000
Placers		589.16	92			
	4,576,827	51,478.64	1,394,365	105,568,000	9,108,804	30,200,000

PLACER OUTPUT.

Placer output in New Mexico in 1917.

County.	Gold.		Silver.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Fine ounces.		*Fine ounces.*		
Colfax	277.62	$5,739	34	$28	$5,767
Grant	152.53	3,153	47	39	3,192
Lincoln	3.10	64			64
Otero	35.65	737	3	2	739
Santa Fe	104.25	2,155	6	5	2,160
Sierra	16.01	331	2	2	333
Total 1917	589.16	12,179	92	76	12,255
Total 1916	537.74	11,116	72	47	11,163
Increase	51.42	1,063	20	29	1,092

CONTENT OF ORES.

Content of copper ores sold or treated in New Mexico in 1917.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Colfax	21		4	3,882	
Dona Ana	66		126	7,660	
Grant	4,132,671	10,266.94	211,353	97,640,974	58,538
Guadalupe	74		40	4,022	
Lincoln	113		74	13,172	
Mora	37		40	6,315	
Otero	8,943	258.28	2,200	476,124	11,994
Rio Arriba	27	.10	392	2,802	
Sandoval	20		153	12,901	
Santa Fe	7,062	338.29	6,763	400,143	
Sierra	47	4.00	50	9,678	
Socorro	36,725	1.01	93,069	2,495,708	21,761
Taos	52	6.04	301	6,748	54
Torrance	2,169	1.45	1,312	200,626	326
	4,188,027	10,876.11	315,877	101,280,755	92,673

Content of dry and siliceous gold and silver ores sold or treated in New Mexico in 1917.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Colfax, Lincoln, and Otero	20,849	17,866.95	5,236	339,514	930
Dona Ana		1.74			
Grant	83,847	9,020.39	228,470	3,215,629	48,000
Santa Fe		6.69	1		
Sierra	45	7.00	4,168	43	
Socorro	116,612	12,540.29	726,460	10,889	161,601
Taos	309	53.65	1,671	95	330
	221,662	39,496.71	966,006	3,566,170	210,861

Content of lead ores sold or treated in New Mexico in 1917.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Dona Ana	351	3.00	4,579	8,461	162,965
Grant	4,325	45.23	16,777	4,862	1,688,538
Luna	1,785	252.08	12,305	319	547,778
Otero	5	.02	4		1,913
Santa Fe	30	1.00	122		5,379
Sierra	502	1.11	695	168	75,500
Socorro	10,428	64.76	35,539	182,140	3,153,745
	17,426	367.20	70,021	195,950	5,635,818

Content of lead-zinc ores sold or treated in New Mexico in 1917.

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Grant	7,449	60.25	9,388	42,317	739,066	394,969
Socorro	3,450				345,000	993,600
	10,899	60.25	9,388	42,317	1,084,066	1,388,569

Content of lead-copper ores sold or treated in New Mexico in 1917.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Grant	3,534	19.74	21,523	469,859	661,389
Sierra	25	59.00	3,797	1,939	4,616
Socorro	125	10.00	4,280	10,574	24,315
	3,684	88.74	29,600	482,372	690,320

Content of zinc ores sold or treated in New Mexico in 1917.

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Grant	83,515				28,946	12,940,158
Luna	3,158		2,837		173,339	1,635,500
Santa Fe	3,067				12,400	512,628
Socorro	45,389	0.47	544	436	1,180,381	13,723,145
	135,129	.47	3,381	436	1,395,066	28,811,431

SMELTERS.

Three smelters were in operation in New Mexico in 1917: The Santa Fe Gold & Copper Co.'s 125-ton matting plant at San Pedro, which was operated on copper ore from its own mines for three months; the Empire Smelting & Refining Co.'s lead plant at Deming, which was operated on lead ores from Arizona and southern New Mexico mines; and the Grubnau, Bryant & Grubnau zinc oxide plant, at Waldo (near Cerrillos), which treated zinc carbonate ores from Arizona, New Mexico, and old Mexico.

The bulk of the copper ore and concentrates mined and produced in New Mexico continued to be shipped to the smelter at El Paso, Tex. Lead ores and concentrates were shipped to Pueblo, Colo. Shipments were also made to the Copper Queen and Calumet smelters, at Douglas, Ariz., and to the smelter at Sasco, Ariz. Zinc ore and concentrates were shipped to smelters and zinc oxide plants in New Mexico, Colorado, Kansas, Oklahoma, Wisconsin, and the Eastern States.

MINING INDUSTRY.

The Mogollon district, Socorro County, remained the most productive silver-mining district, despite a decrease in output, but continued to take second place to the Elizabethtown district, Colfax County, in production of gold. The Elizabethtown (Baldy) district continued to produce much high-grade metallic gold, gold bullion, and concentrates from the Aztec mine, at Baldy, as well as small quantities of placer gold from near Elizabethtown. The Lordsburg and Pinos Altos districts, Grant County, made a decreased output of both gold and silver, as did the Orogrande district, Otero County, and the San Pedro district, Santa Fe County. No production was made in the silver-gold Cochiti (Bland) district, Sandoval County. The amalgamation mill at the Homestake mine, Whiteoaks, Lincoln County, continued to be operated, and the new Parsons amalgamation mill, at Nogal, Lincoln County, was in operation for a period.

Copper continued to be the principal product of New Mexico mines in 1917 when it made the largest output on record. The Chino Copper Co., which since 1910 has been mining with steam shovels large low-grade copper deposits at Santa Rita, reports that during the year 1917 there were treated in the large milling plant at Hurley a total of 3,608,100 tons of ore, equivalent to 9,885 tons a day. The Burro Mountain 1,000-ton mill (first set in operation in April, 1916) produced in 1917 a greatly increased quantity of copper concentrates. The production of copper decreased in the Lordsburg, Orogrande, Organ Mountains, and San Pedro districts, but the high prices for copper resulted in continued scattered shipments from the deposits in the "Red Beds" of New Mexico.

The output of lead increased 894,615 pounds. Large quantities of lead carbonate and of lead-zinc sulphide ores were shipped from the Magdalena district, Socorro County; lead ores were shipped from the Cooks Peak, Florida Mountains, and Victorio districts, Luna County; from the Central and San Simon districts, Grant County; from the Caballos Mountains, Sierra County; and from the Organ Mountains, Dona Ana County.

The output of zinc decreased 6,370,649 pounds. At Kelly the new Graphic mill, built to replace the one destroyed by fire in 1916, was operated from March throughout the year, and the Kelly mill was also operated. At Hanover and Cleveland both mills were in operation throughout the year. The Tom Payne mill, near Cerrillos, was also in operation. Zinc carbonate ores shipped from Kelly, Cooks Peak, Hanover, Florida Mountains, and Tres Hermanas, were much less than in 1916.

Mine production of gold, silver, copper, lead, and zinc in New Mexico in 1917.

County.	Number of mines producing.	Ore.	Gold.[a]		Silver.[a]	
			Quantity.	Value.	Quantity.	Value.
		Short tons.	*Fine ounces.*		*Fine ounces.*	
Colfax and Lincoln..........	11	11,940	17,268.67	$356,975	2,705	$2,229
Dona Ana....................	5	417	4.74	98	4,705	3,877
Grant.......................	68	4,315,341	19,565.08	404,446	487,558	401,748
Guadalupe...................	3	74	....	....	40	33
Luna........................	10	4,943	252.08	5,211	15,142	12,477
Mora........................	1	37	....	....	40	33
Otero.......................	19	17,991	1,172.95	24,247	4,850	3,996
Rio Arriba..................	4	27	.14	3	392	323
Sandoval....................	1	20	....	....	153	126
Santa Fe....................	12	10,159	450,23	9,307	6,892	5,679
Sierra......................	13	619	87.12	1,801	8,712	7,179
Socorro.....................	28	212,729	12,616.49	260,806	859,892	708,551
Taos........................	3	361	59.69	1,234	1,972	1,625
Torrance....................	14	2,169	1.45	30	1,312	1,081
Total, 1917.............	192	4,576,827	51,478,64	1,064,158	1,394,365	1,148,957
Total, 1916.............	210	3,870,950	66,877.47	1,382,480	1,766,274	1,162,208
Increase or decrease, 1917..........	....	+705,877	−15,398.83	−318,322	−371,909	−13,251

[a] Includes placer production.

County.	Copper.		Lead.		Zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Colfax and Lincoln.	17,956	$4,902	930	$80	....	....	$364,186
Dona Ana..........	16,121	4,401	162,965	14,015	....	....	22,391
Grant..............	101,373,641	27,675,004	3,224,477	277,305	13,335,127	$1,360,183	30,118,686
Guadalupe..........	4,022	1,098	....	....	....	....	1,131
Luna...............	319	87	721,117	62,016	1,635,500	166,821	246,612
Mora...............	6,315	1,724	....	....	....	....	1,757
Otero..............	814,736	222,423	13,907	1,196	....	....	251,862
Rio Arriba.........	2,802	765	....	....	....	....	1,091
Sandoval...........	12,901	3,522	....	....	....	....	3,648
Santa Fe...........	400,143	109,239	17,779	1,529	512,628	52,288	178,042
Sierra.............	11,828	3,229	80,116	6,890	....	....	19,099
Socorro............	2,699,747	737,031	4,886,803	420,265	14,716,745	1,501,108	3,627,761
Taos...............	6,843	1,868	384	33	....	....	4,760
Torrance...........	200,626	54,771	326	28	....	....	55,910
Total, 1917....	105,568,000	28,820,064	9,108,804	783,357	30,200,000	3,080,400	34,896,936
Total, 1916....	92,747,289	22,815,833	8,214,189	566,779	36,570,649	4,900,467	30,827,767
Increase or decrease, 1917.	+12,820,711	+6,004,231	+894,615	+216,578	−6,370,649	−1,820,067	+4,069,169

Gold and silver produced at mills in New Mexico, 1909–1917.

Year.	Ore to gold and silver mills.	Gold in bullion.	Silver in bullion.	Ore to concentrating mills.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Short tons.*
1909	32,830	6,725.84	169,650	78,782
1910	67,148	14,220.94	412,272	61,379
1911	109,113	21,894.14	771,014	59,622
1912	106,208	20,342.58	842,018	1,142,002
1913	124,536	24,891.37	1,024,363	1,987,896
1914	156,913	29,730.64	1,161,455	1,955,881
1915	149,650	40,474.37	1,129,701	2,428,344
1916	135,267	34,332.33	841,865	3,442,681
1917	123,824	26,270.55	657,437	4,215,988
Increase or decrease, 1917	−11,443	−8,061.78	−184,428	+773,307

Mine production of metals from New Mexico concentrates, 1909–1917.

Year.	Concentrates produced.					
	Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
1909	7,554	1,598.31	112,639	2,015,118	436,558	821,766
1910	18,298	4,536.03	255,060	1,050,238	2,701,843	6,882,175
1911	16,243	7,938.70	833,654	1,125,927	1,562,768	5,304,000
1912	81,811	7,190.63	290,081	28,760,908	1,984,435	6,404,768
1913	198,243	7,913.39	294,948	51,723,923	1,076,848	8,594,183
1914	161,003	12,754.17	312,734	53,398,611	637	8,541,261
1915	174,074	12,876.72	323,402	66,326,554	75,580	11,179,266
1916	311,726	13,125.69	336,472	80,235,404	727,888	16,625,663
1917	360,614	10,167.96	196,713	92,990,700	2,108,154	21,130,965
Increase or decrease, 1917	+48,888	−2,957.73	−139,759	+12,755,296	+1,380,266	+4,505,302

Mine production of metals from New Mexico crude ore shipped to smelters, 1909–1917.

By years.

Year.	Crude ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
1909	52,544	2,196.50	115,332	3.378,028	4,593,209	12,264,179
1910	63,338	3,317.99	176,281	3,564,148	1,618,998	11,205,954
1911	63,964	6,162.71	249,710	2,931,113	1,403,454	4,933,176
1912	104,076	9,595.57	404,462	5,270,056	3,509,583	7,161,869
1913	105,228	9,478.13	311,872	4,584,783	2,869,516	7,928,978
1914	120,059	12,785.76	302,926	5,909,314	1,763,004	9,862,131
1915	219,078	16,882.78	552,373	10,461,812	4,466,781	14,224,798
1916	293,002	18,881.71	587,865	12,514,885	7,486,301	19,944,986
1917	237,015	14,450.93	540.123	12,577,300	7,000,650	9,069,035
Increase or decrease, 1917	−55,987	−4,430.78	−47,742	+62,415	−485,651	−10,875,951

By kind of ores (in 1917).

Dry and siliceous	91,838	9,919.90	238,122	3,559,076	9,167	....
Copper	104,509	4,075.09	199,543	8,339,902	92,673	....
Lead	17,426	367.20	70,021	195,950	5,635,818	....
Copper-lead	3,684	88.74	29,600	482,372	690,320	....
Zinc	15,963	....	2,837	....	210,585	8,015,397
Zinc-lead	3,595	....	....	....	362,087	1,053,638

Mine production of metals from New Mexico crude ore shipped to smelters, 1917.

County.	Crude ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Colfax	21		4	3,832		
Dona Ana	417	3.00	4,705	16,121	162,965	
Grant	145,144	12,528.98	361,867	8,425,314	2,454,498	1,829,242
Guadalupe	74		40	4.022		
Lincoln	114	9.91	90	13,172		
Luna	4,943	252.08	15,142	319	721,117	1,635,500
Mora	37		40	6,315		
Otero	16,016	1,137.30	4,752	779,893	13,907	
Rio Arriba	27	.10	392	2,802		
Sandoval	20		153	12,901		
Santa Fe	7,162	339.29	6,885	400,143	10,179	26,884
Sierra	619	71.11	8,710	11,828	80,116	
Socorro	60,191	78.10	134,993	2,693,119	3,557,158	5,577,409
Taos	61	29.61	1,038	6,843	384	
Torrance	2,169	1.45	1,312	200,626	326	
	237,015	14,450.93	540,123	12,577,300	7,000,650	9,069,035

Gold and silver contained in bullion produced at mills in New Mexico, 1917.

Process.	Quantity.	Gold in bullion.	Silver in bullion.
	Short tons.	*Fine ounces.*	*Fine ounces.*
Amalgamation	11,890	14,866.81	2,256
Cyanidation	111,934	11,403.74	655,181
	123,824	26,270.55	657,437

The quicksilver consumed in New Mexico in 1917 amounted to 175 pounds, representing 1 pound for every 85 ounces of gold, and the sodium cyanide to 123,500 pounds, representing 1 pound for every 0.09 ounce of gold and 1 pound for every 5.30 ounces of silver.

REDUCTION MILLS.

Mineral Resources for 1912, Part 1, pages 832–835, contained a complete list of the reduction mills in New Mexico in 1912 and descriptions of equipment and process. Changes in this list for 1913–1917 have been noted in the text for the several counties for each year, and reference should be made to the 1912 report for details of equipment.

REVIEW BY COUNTIES.[1]

BERNALILLO COUNTY.

Assessment and development work only was done in the Coyote, Hell Canyon, and Soda Springs districts.

COLFAX COUNTY.

Elizabethtown district (including Baldy).—The Aztec mine[2] at Baldy continued to ship gold bullion and concentrates carrying a high content of gold from the 10-stamp amalgamation-concentration mill on the property. Several placer mines were operated during the year at Elizabethtown. The following table shows the production of Elizabethtown and Baldy districts (which is the output for Colfax County) from 1904 to 1916, inclusive:

---

[1] For discussion of geology of the districts mentioned in the following pages the reader is referred to Hill, J. M., The mining districts of the western United States: U. S. Geol. Survey Bull. 507, 1912; and Lindgren, Waldemar, The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, 1910.

[2] Lee, W. T., The Aztec gold mine, Baldy, N. Mex.: U. S. Geol. Survey Bull. 620, pp. 325–330, 1916.

Mine production in Elizabethtown district, Colfax County, N. Mex., 1904–1917.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Total value.
		Placer.	Deep.				
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	380	$90,639	$3,638	67	....	....	$94,316
1905	13	31,994	445	157	....	....	31,749
1906	....	14,492	....	93	....	....	14,554
1907	....	11,914	....	83	....	....	11,969
1908	....	11,274	....	66	....	....	11,309
1909	83	16,037	1,705	127	....	....	17,808
1910	93	9,588	3,433	261	....	2,182	13,258
1911	2,306	9,860	31,547	1,254	5,587	....	42,770
1912	3,025	8,385	27,316	634	6,243	....	37,121
1913	3,222	4,550	15,588	254	1,147	134	20,475
1914	2,860	4,930	63,129	577	11,083	154	69,858
1915	2,673	2,631	350,745	2,483	14,092	787	357,138
1916	6,064	5,039	417,258	2,803	447	....	424,251
1917[a]	....	....	....	....	....	....	....

[a] Combined with Lincoln County.

DONA ANA COUNTY.

Mine production in Dona Ana County, N. Mex., 1904–1917.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	5,580	....	24,101	40,000	1,581,488	....	$87,145
1905	6,566	$6,710	21,776	96,058	327,707	30,000	52,020
1906	16,220	....	34,051	434,000	1,207,193	....	175,386
1907	6,084	6	25,612	776,125	675,189	....	207,920
1908	3,090	....	9,283	21,150	379,697	....	23,660
1909	2,816	248	16,975	10,600	772,023	....	43,650
1910	2	....	15	....	705	....	39
1911	5	....	111	363	1,561	....	173
1912	78	17	1,790	6,685	26,129	....	3,397
1913	155	80	1,232	10,189	9,557	....	2,774
1914	451	927	3,564	78,180	29,897	....	14,462
1915	1,599	2,426	8,335	241,749	19,170	....	49,859
1916	2,615	503	7,948	206,187	34,696	106,679	73,144
1917	417	98	4,705	16,121	162,965	....	22,391
Increase or decrease, 1917.	−2,198	−405	−3,243	−190,066	+128,269	−106,679	−50,753

Organ Mountains district.—The only large producers were the mines of the Stephenson-Bennett group, under lease to the American Smelting & Refining Co. During November and December, 1917, this company shipped lead ore to the El Paso smelter and lead-zinc ore to Coffeyville, Kans. The Phelps Dodge Co., which had an option on this mine and others during 1916, relinquished the option early in 1917 and made no shipments of ore in 1917. Other mines from which small shipments were made in 1917 were the Modoc and Excelsior.

GRANT COUNTY.

Mine production in Grant County, N. Mex., 1904–1917.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Zinc.	Total value.
		Placer.	Deep.					
	Short tons.			*Fine ozs.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	47,032	$8,081	$60,347	74,793	4,428,508	179,142	....	$695,099
1905	81,160	10,943	35,064	86,629	5,291,222	321,035	257,203	954,026
1906	127,800	2,290	97,519	163,987	6,388,830	710,895	144,656	1,492,069
1907	146,746	3,782	109,260	224,279	8,046,315	1,394,390	73,729	1,948,582
1908	75,254	3,514	42,168	95,477	5,242,767	244,589	251,070	810,403
1909	89,576	3,584	34,242	74,198	5,176,585	215,070	203,278	760,590
1910	70,862	2,641	63,291	156,557	4,404,394	257,953	1,285,500	790,598
1911	93,770	4,043	112,241	221,882	3,918,928	694,247	306,895	772,481
1912	1,200,691	2,551	163,645	356,057	32,952,133	2,309,732	3,135,000	6,142,526
1913	1,984,304	1,646	102,971	206,215	53,436,177	446,805	2,553,322	8,674,423
1914	1,986,921	21,560	319,300	304,679	58,259,113	570,513	3,734,768	8,448,810
1915	2,523,275	1,979	363,104	508,552	72,487,200	2,251,383	6,083,580	14,168,358
1916	3,577,868	2,009	417,666	549,907	87,784,545	2,561,638	14,084,843	24,440,634
1917	4,315,341	3,153	401,293	487,558	101,373,641	3,224,477	13,335,127	30,118,686
Increase or decrease, 1917	+737,473	+1,144	−16,373	−62,349	+13,589,096	+662,839	−749,716	+5,678,052

Apache No. 2 (Anderson) district.[1]—Shipments of silver-copper ore were continued throughout the year from the Apache mine, southeast of Hachita.

Black Hawk district.—At the Black Hawk mine, reopened in 1916 after many years of idleness, the year 1917 was spent in pumping, timbering, sampling, and drifting. This property is opened by a 720-foot incline shaft, and 4,880 feet of drifts.

Burro Mountain district.[2]—The annual report (dated Feb. 11, 1918) of Phelps-Dodge Corporation, for the calendar year 1917, says of the Burro Mountain Branch mines and the 1,500-ton water and flotation concentrating mill:

> The net production of copper and silver, based on smelter returns from shipments of concentrates, precipitates, and lease ore, was as follows:

	Quantity.	Copper.		Silver.
	Dry tons.	*Per cent.*	*Pounds.*	*Ounces.*
Concentrates	45,681	14.775	12,823,641	39,403.57
Precipitates	303	54.855	315,412	....
	45,984	....	13,139,053	39,403.57
Lease ore	12,485	4.4626	1,114,338	....
	58,469	....	14,253,391	39,403.57

> The ore mined for delivery to the concentrator was 473,443 tons, having an assay value of 1.972 per cent. The cost of mining a ton of ore shows a reduction as compared with the previous year, but this improvement is more than counterbalanced by a drop in the grade of the ore from 2.117 per cent in 1916. Much of the necessary expense of placing the stopes in economical condition to extract ore has been absorbed in the past costs of mining, and a marked improvement in costs should be experienced in this respect in the future.

---

[1] As distinguished from Apache (Chloride) district, Sierra County.

[2] Paige, Sidney, Metalliferous ore deposits near the Burro Mountains, Grant County, N. Mex.: U. S. Geol. Survey Bull. 470, pp. 131–150, 1911: also U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), 1916, Weed, W. H., The copper mines of the United States in 1905: U. S. Geol. Survey Bull. 285, p. 118, 1906. Somers, R. E., Geology of the Burro Mountains: Am. Inst. Min. Eng. Bull. 101, pp. 957–996, 1915. Bush. F. V., Burro Mountain porphyry copper developments: Min. and Sci. Press, Feb. 6, 1915, pp. 222–224.

The ore reserves have been substantially increased and the stopes themselves have been put into condition for more economical operation.

The results of concentrator operations for the year are shown below:

Ore milled, 473,443 tons dry weight, assaying 1.972 per cent copper.
Moisture of general heads, 3.329 per cent.
Copper in ore milled, 9,334.948 tons.
Concentrates produced, 45,681 tons dry weight, assaying 14.775 per cent copper.
Tailings produced, 427,762 tons dry weight, assaying 0.606 per cent copper.
Saving (average of four methods of figuring), 72.256 per cent.
Yield, 1.426 per cent.
Ratio of concentration, 10.364.
Tons of ore milled per day, actual running time, 1,485.218.
Gallons fresh water used per ton ore milled, 748.101.
Kilowatt hours per ton of ore milled, 9.222.

Churn drilling operations continued at a reduced rate throughout the year, and satisfactory ore discoveries were made at several points of the property. On the Michigan and Manana claims ore was cut by two holes placed within the general trend of the mineralized zone, and by these discoveries the possibility of continuous ore between No. 11 stope and the Mohawk ore body, 1,800 feet to the northeast, is materially strengthened.

Systematic drilling has been started on the properties of the Azure Mining Co., which is held under option, but without, as yet, very encouraging results.

A total of 30,542 feet was drilled during the year, 52 holes having been sunk an average depth of 587.4 feet.

The leaching operations on the old ore dump at No. 2 shaft yielded about 280,090 pounds of copper, or about 25 per cent of its original content. Exhaustive experiments will be undertaken during the year to determine whether it will be practical to leach on a large scale the very considerable tonnage of ore below milling grade which exists in these properties. With the hope of further information as to the possibilities of the process, plans are now under way for a new series of ore heaps of varying size and depth to be located in the flat below the mill. Facilities will be provided for the proper make-up and control of leaching solutions and efforts made to determine the suitable chemical and physical operating conditions for the best results.

The Phelps Dodge Corporation also maintains and controls the town site, upon which it has built a model town. The only other producing property of importance was the Austin-Amazon group, from which a considerable quantity of copper-silver ore was shipped.

Central district.[1]—The Central district, embracing the towns of Bayard, Fierro, Georgetown, Hanover, and Santa Rita, not only makes the most valuable output of ore in New Mexico, but produces the most interesting variety of ores. Besides the Chino Copper Co.'s mines at Santa Rita, the Empire Zinc Co.'s mines at Hanover, and the Hanover-Bessemer Iron and Copper Co.'s mines at Fierro, there were 24 other producing mines in the district in 1917. From the dumps of the Hanover and Modoc mines a considerable quantity of oxidized ore, low in copper but high in iron, was shipped as iron fluxing ore for the Copper Queen smelter, at Douglas, Ariz. Zinc carbonate ore was shipped from the Hanover mines of the Empire Zinc Co., the Hanover Copper Co.'s group, the Belle, the Mountain Home group, and from others. Both oxidized and sulphide copper was shipped from the Dewey and Schley mines; copper ore from the Copper Rose, Edmonson, Philadelphia, and San Jose mines; copper and lead-copper ore from the Groundhog and the Ivanhoe; and lead oxidized ore of good grade and in considerable quantity from the Lucky Hill mine. Iron ore to the steel mill at Pueblo, Colo., and to the lead smelters at Deming was shipped by the Republic Mining

---

[1] Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio (199), 1916: The Hanover iron-ore deposits. New Mexico: U. S. Geol. Survey Bull. 380, pp. 199-214, 1909. Birkinbine, John, Iron ores of the United States: U. S. Geol. Survey Eighteenth Ann. Rept. pt. 5 pp. 48-50, 1897.

& Milling Co. This company also developed a large body of zinc sulphide ore.

The Hanover-Bessemer Iron & Copper Co., owner of the iron mines at Fierro, for many years leased to the Colorado Fuel & Iron Co., of Pueblo, Colo., built an electrostatic separation mill in 1917 for the treatment of the iron ores, with a resultant separation of copper products as well.

The Empire Zinc Co. also operated steadily its magnetic separating mill [1] at Hanover on zinc sulphide ores from its mines.

The Gold Gulch concentration mill, built in 1916, on Santa Rita Creek, near Bayard, was operated in 1917 on lead-zinc ore from the Booth, Gold Gulch, and Jack Mining Co.'s mines.

The Chino Copper Co. is mining a low-grade copper deposit at Santa Rita by steam shovels. The ore is concentrated at Hurley, where the company's wet-concentration-flotation mill is located. Concentrates and occasional cars of ore are shipped principally to the El Paso smelter. The eighth annual report of the Chino Copper Co., dated March 5, 1918, covering the year ended December 31, 1917, says:

> The gross production for the year of copper in concentrates and direct shipments, including a small amount of precipitates, was 83,339,782 pounds. After making smelter deductions the net production was 79,636,235 pounds. There was also produced gold and silver valued at $56,160. These net figures were the result of handling during the year 3,608,100 tons through the mill and 3,757 tons of direct shipping ore.
>
> The net cost of producing copper for the year * * * was 11.39 cents per pound as compared with 8.7 cents for 1916. This was after deducting precious metal values and miscellaneous earnings for the year, which amounted to 0.46 cent per pound, from the cost of producing copper. Taxes accrued and included in operating expenses during the year were insufficient by $830,996 to cover the total of $2,033,439 for all 1917 taxes as now estimated and returned to the proper officials. The total cost, including, as usual, all taxes as last stated and also including the adjustment to income from stripping account noted below, was 12.79 cents per pound. Higher prices for labor and supplies and increases in taxes in 1917 are responsible for this considerable advance in cost of production. * * *
>
> The net income from operations was $9,826,616. Miscellaneous income, dividends, rentals, etc., amounted to $310,436, or a total income from all sources of $10,137,052. There was a direct charge to income for plant alterations, replacements, and abandonments and depreciation adjustment of $336,077; also an amount of $288,121 for adjustment of charges to stripping account. * * * The total income, therefore, applicable to dividends or other capital purposes aggregated $9,512,854, or $10.93 per share, as compared with $14.76 per share for the year 1916. Disbursements to stockholders were made during the first three quarters at the quarterly rate of $2.50 per share and for the last quarter at $2 per share; in addition a Red Cross dividend of 40 cents per share was paid, making total disbursements to stockholders during the year of $9.90 per share. The total amount distributed to stockholders during the year was $8,612,802. An amount for depreciation of plants of 5 per cent of their total cost was set aside and included in operating expenses. The entire operations outlined above resulted in passing $900,052 to the "earned surplus" and "depletion" account, which at the end of the year aggregated $14,863,926. The total disbursements to stockholders down to and including December 31, 1917, were $22,488,132. * * *
>
> Churn drilling was continued throughout the year, the three drills operating in the Northwest and Southwest ore bodies. Extensions of the ore bodies were demonstrated. The total driling for the year was 22,425 feet, and since the beginning of operations there has been a total of 249,728 feet drilled. * * *
>
> The prospect drilling for this year has shown additional commercial ore in excess of the tonnages removed. A considerable proportion of this new ore lies within the pit slopes as heretofore laid out. Revised calculations of total ore reserves were not made because the time and expense of doing so did not seem warranted, and it can only be stated, therefore, that the remaining reserves at the end of 1917 exceed those at

---

[1] For description see Met. and Chem. Eng., Oct. 10, 1916, pp. 481-482.

the end of 1916, which were reported at that time to be 95,555,843 tons, averaging 1.656 per cent copper.

During the month of May, 1917, the second unit of the primary crushing plant at the mine was finished and placed in successful operation. In order to provide equipment for moving the additional ore tonnages to this plant, 16 automatic air dump cars of 20-yard capacity were ordered early in the year and are received as required. * * *

During the year the three upper stripping benches of the Hearst pit were completed back to the point to allow ample slope for the recovery of the steamshovel ore. This work was also completed on the upper benches of the Northwest and North ore bodies. The shovels thus released were moved to the Southwest ore body and work on the top benches of that ore body started.

The total amount of ore and waste removed by the steam shovels during the year was 5,583,016 cubic yards of material in place. Of this amount 3,712,414 cubic yards was stripping, the remainder being equivalent to 3,607,825 tons of ore. Of the ore that was removed, 3,604,068 tons were sent to the mill, and 3,757 tons were shipped direct to the smelter, these direct shipments averaging 18.27 per cent copper. During the year there was no ore sent to the ore dumps; on the other hand, there were 3,271 tons taken from the ore dumps and sent to the mill for experimental purposes, so that the total shipments to the mill were 3,607,339 tons. The ore remaining on the ore dumps at the mine at the close of the year was 1,061,636 tons.

From the beginning of steam shovel operations on September 23, 1910, when the first shovel was erected, there was removed a total of 28,378,348 cubic yards of material in place, of which 20,599,199 cubic yards were stripping, the remainder being equivalent to 15,194,517 tons of ore. Of this ore 1,061,636 tons remain stored in the stock piles at the mine, 14,109,194 tons were shipped to the mill, the balance, 23,687 tons, having been shipped directly to the smelter. * * *

Following the plans made and approved in 1916 covering additions to and alterations in the original five-section mill and the addition of two sections, work was contined on these improvements throughout the year. The alterations and additions to the original mill were completed and the concentrating machinery put completely in service for all five sections during the latter part of May. The power plant additions were completed and the turbo-generator set placed in service at practically the same time. The completion of these improvements, as well as the putting in service of the second unit of the primary crushing plant at Santa Rita, resulted immediately in the treating of additional tonnages, amounting to an increase of over 11 per cent for the balance of the year. Construction work on sections 6 and 7 was pushed as fast as the machinery and material could be obtained, with the result that in the latter part of December the fine crushing machinery and part of the concentrating machinery were in operation in section 6, though the full benefit of this section can not be felt until about the 1st of February, 1918. As a result of the work with the 100-ton experimental plant it was possible to outline a flow sheet for section 7 in handling the oxidized and partly oxidized ores. The necessary apparatus has been ordered and the installation will be completed as quickly as such material as is not on hand is received. A part of the floor space of section 7 will be devoted to the regular milling operations and the other part will be equipped with the special apparatus which has been decided on, in order that further work on at least a 500-ton basis may be carried on. The tailings retreatment plant construction was not continued to completion, as, owing to developments in the experimental plant, it was deemed wise to await the result of the new line of work which had been indicated by larger scale investigations. During the year the canal was completed to take care of the overflow of flood waters from the tailings and water storage dam and the railroad track for handling the material to and from the tailings mill was in service. * * *

For the year 1917 there was treated in the mill at Hurley a total of 3,608,100 tons of ore, equivalent to an average of 9,885 tons per day. Previous to June 1 the average per day was 9,285 tons. Subsequent to June 1 the average per day was 10,308 tons. The average treated per day for 1916 was 8,455 tons, so that there was an average increase for 1917 over 1916 of 1,430 tons per day, or 16.9 per cent. The average content of the ore treated for the year was 1.64 per cent copper, or 0.19 per cent lower than for 1916. The total production of concentrates was 264,765 tons, which averaged 15.47 per cent copper. The total amount of copper contained in concentrates was 81,925,809 pounds, being an increase of 8.44 per cent over 1916 and corresponding to a recovery of 22.706 pounds of copper per ton of ore, equivalent to an extraction of 69.32 per cent, which was 2.73 per cent better than for the year 1916, notwithstanding the increased tonnage and lower grade ore. The average cost of milling was $1.03 per ton, as against a cost for 1916 of 64 cents per ton. Mill supplies show an increase of 42.2 per cent in cost per ton. Power costs increased 47.3 per cent, due principally to the advance in prices paid for fuel.

During the year there were shipped from the mine direct to the smelter 3,757 dry tons of ore and 48.5 dry tons of precipitates containing 1,413,973 gross pounds of copper.

The production of copper contained in the concentrates and other shipping products for the year 1917, by quarters, was as follows:

	Pounds.
First quarter	19,240,577
Second quarter	21,944,094
Third quarter	21,887,390
Fourth quarter	20,267,721
	83,339,782

The average cost of net copper produced for the year, after making deductions for smelter allowances and crediting precious metal values and miscellaneous income, was 11.39 cents per pound, as compared with 8.7 cents per pound for the previous year. The credit for precious metals amounted to 0.07 cent per pound and that of miscellaneous income to 0.39 cent per pound, a total of 0.46 cent per pound. The per pound cost stated includes depreciation and reserves for taxes set up during the year, the latter being, however, insufficient to meet actual requirements and therefore subject to adjustment against income.

Mine production in Central district, Grant County, N. Mex., 1904–1917.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	21,048	$5,582	282	3,264,208	11,977	....	$430,607
1905	17,115	....	....	2,704,233	....	....	421,860
1906	39,155	4	1,524	3,075,001	235,070	99,656	614,648
1907	57,079	5,659	36,813	4,994,575	855,358	73,729	1,078,555
1908	41,852	777	296	3,994,502	29,122	251,070	541,231
1909	41,456	816	1,380	3,348,808	23,256	203,278	448,856
1910	37,008	....	404	2,679,630	155	1,285,500	409,955
1911	45,584	104	8,673	1,413,189	605,978	290,122	325,156
1912	1,136,290	998	29,586	29,512,812	2,172,676	2,205,824	5,138,779
1913	1,948,471	9,697	12,500	51,695,656	331,440	2,187,266	8,167,144
1914	1,934,020	102,971	42,971	55,222,874	365,079	3,669,513	7,672,759
1915	2,395,795	102,379	73,267	66,581,366	1,542,234	5,628,870	12,561,729
1916	3,134,791	133,962	116,953	74,228,606	2,122,797	7,278,575	19,592,956
1917	3,668,289	138,873	121,386	82,200,421	2,250,337	7,398,853	23,627,822
Increase, 1917	533,498	4,911	4,433	7,971,815	127,540	120,278	4,034,866

Chloride Flat district (near Silver City).—No silver ores were shipped from this formerly producing district, but iron-manganese ores[1] in considerable quantity were shipped during the year.

Eureka district (including Sylvanite).—One car of zinc carbonate ore was shipped from the Sheridan mine and one car of lead-silver ore from the Natches mine.

Fremont district.[2]—One car of zinc-lead carbonate was shipped from the Doyle prospect.

Gold Hill district.—The Cline two-stamp amalgamation mill was operated for two months and produced gold-silver bullion.

Lordsburg district (including Pyramid and Virginia or Shakespeare districts).—The production of this district in 1917 was a little less than in 1916, the record year in the history of the district. All the ore was shipped direct to smelters. The average assay for the district in 1917 was gold 0.1194 ounce and silver 2.97 ounces per ton, and copper 2.14 per cent. The principal producing property was the group operated by the Eighty-five Co. This company in 1917 was also engaged in building a 500-ton gravity and oil flotation mill, to be completed in 1918. Increased shipments of copper were made from the Bonney mine. Other producing mines were the Atwood and Nellie Bly.

---

[1] See Eng. and Min. Jour., Nov. 24, 1917, p. 931.

[2] Darton, N. H., Geology and underground water of Luna County, N. Mex.: U. S. Geol. Survey Bul. 618, pp. 106–107, 1916.

Mine production in Lordsburg district, Grant County, N. Mex., 1904–1917.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	250	$1,184	2,580	18,200	12,000	$5,582
1905	366	10	7,584	48,000	....	12,079
1906	1,743	5,168	27,261	212,601	....	64,465
1907	5,645	8,761	31,303	463,335	10,522	122,646
1908	7,532	10,617	9,889	259,079	11,363	50,534
1909	10,090	25,983	50,151	589,969	8,862	129,140
1910	29,220	59,798	130,324	1,627,591	19,662	337,742
1911	46,139	106,648	182,448	2,455,336	2,157	510,359
1912	55,340	144,859	275,251	3,155,585	4,562	835,015
1913	31,284	55,234	154,779	1,601,461	14,572	397,588
1914	38,964	101,080	232,647	2,614,674	30,049	578,658
1915	92,093	222,848	374,325	3,890,365	28,723	1,094,795
1916	118,966	267,148	373,074	4,755,179	30,478	1,684,508
1917	99,532	245,607	295,443	4,261,956	41,442	1,656,130
Increase or decrease, 1917	−19,434	−21,541	−77,631	−493,223	+10,964	−28,378

Pinos Altos district.[1]—The only important decrease in the production for 1917 was for copper. Placer gold production increased.

The Cleveland zinc mine and magnetic separation mill was operated steadily, the product being entirely zinc concentrate. Lead and zinc ore was shipped from the Lead Hill mine, and a car of lead-zinc ore from the Calumet mine. A considerable quantity of silver ore was shipped from the Manhattan mine. Lessees on the Mina Grande, Pacific, and Atlantic groups shipped some silver-copper ore.

Mine production in Pinos Altos district, Grant County, N. Mex., 1904–1917.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Zinc.	Total value.
		Placer.	Deep.					
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	4,719	$7,750	$49,660	37,229	104,069	2,653	....	$92,587
1905	6,348	10,943	31,442	39,585	103,469	....	160,779	82,442
1906	14,074	2,290	89,674	83,566	328,788	....	....	211,409
1907	14,841	3,782	78,723	65,862	322,195	....	....	190,413
1908	1,451	1,479	8,548	8,941	34,514	3,953	....	21,528
1909	38	3,584	2,083	1,377	6,200	418	....	7,207
1910	20	2,494	1,372	223	269	2,226	....	4,119
1911	355	4,043	1,406	5,616	3,232	4,063	16,773	9,968
1912	6,169	[a] 2,551	7,973	15,864	96,507	50,289	929,176	102,581
1913	3,643	1,646	29,162	28,276	100,555	83,067	366,056	87,626
1914	3,686	[a] 21,650	114,181	23,256	129,587	29,994	48,840	169,497
1915	7,024	1,979	31,823	19,856	377,463	130,638	454,710	172,463
1916	46,471	2,009	11,775	17,816	122,716	152,696	6,741,925	967,621
1917	45,993	3,153	7,731	10,803	49,945	80,989	5,556,892	607,189
Increase or decrease, 1917	−478	+1,144	−4,044	−7,013	−72,771	−71,707	−1,185,033	−360,432

[a] Placer and surface lode mines combined. Only small quantity recovered by actual placer methods. Fineness so similar separation not practicable.

---

[1] Paige, Sidney, The ore deposits near Pinos Altos, N. Mex.: U. S. Geol. Survey Bull, 470, pp. 109-125, 1911; U. S. Geol. Survey Geol. Atlas Silver City, folio (No. 199), 1916.

San Simon (Granite Gap) district (Steins).—Several cars of ore were shipped from this district in 1917—lead ore from the Granite Gap mine, lead-zinc ore from the Silver Hill, copper ore from the Johnny Bull, and copper ore from the Hamilton group.

Steeplerock district.—From the 500-foot level of the Carlisle mine (unwatered and opened in 1916 after a long idleness) was mined and milled several thousand tons of lead-zinc ore, the product being lead-zinc and lead concentrates, both of which also contained silver and some copper. Several cars of copper ore were shipped from the Delmire group and a car of silver ore from the Jim Crow group.

Swarts (Carpenter or Camp Monarch) district.—During three months the Monarch mill (built in 1906) was operated on lead-zinc ore from open-cut mining at the Grand Central mine. This mine is also opened by an incline shaft.

GUADALUPE COUNTY.

Several cars of copper-silver ore were shipped from the Pintada district. The plans for leaching the ores of this district seem to have been abandoned.

LINCOLN COUNTY.

Mine production in Lincoln County, N. Mex., 1904–1917.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Total value.
		Placer.	Deep.				
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	820	$20,100	$8,496	2,576	....	2,261	$30,183
1905	3,060	2,260	5,215	757	14,404	7,511	10,532
1906	6,380	....	16,463	1,946	....	....	17,767
1907	5,767	....	41,417	721	....	....	41,893
1908	4,399	816	28,896	5,472	1,195	....	32,770
1909	3,633	472	23,391	388	700	7,977	24,499
1910	10,727	1,400	53,876	559	189	5,614	55,849
1911	1,578	1,629	30,305	184	555	6,620	32,399
1912	2,003	1,008	21,408	1,005	9,988	103,911	29,358
1913	5,589	1,027	41,469	1,100	7,068	94,010	48,392
1914	13,540	908	62,499	961	15,068	10,641	66,360
1915	8,550	1,308	44,068	493	5,091	13,277	47,141
1916	1,490	651	7,093	953	28,045	....	15,270
1917	(a)	(a)	(a)	(a)	(a)	....	(a)

[a] Combined with Colfax County.

Estey district (Oscuro Mountains).—Several cars of copper were shipped from the Walter Mayfield group.

Jicarilla district.—There was a small production of placer gold in this district.

Nogal district.—The 250-ton amalgamation mill, completed early in 1917 to treat the ores of the Hopeful mine, was operated for a period. The Vera Cruz amalgamation mill (built in 1902), 4 miles south of Nogal, was rebuilt during the year, with plans for operating in 1918. The rebuilt mill will have a capacity of 50 tons a day, and the equipment consists of one Blake crusher, one Ellis ball Chilean mill, one Senn amalgamator, and 10 tanks for dewatering and for proposed future treatment of tailings by cyanidation.

Whiteoaks district.—During the later half of the year the Homestake 20-stamp amalgamation mill was operated on ore from the North Homestake and South Homestake mines.

The area is part of an oval mass of coarse-textured hornblende granite, 8 miles northwest-southeast by 5 miles northeast-southwest, containing inclusions of epidiorite and felsite dikes.

The tungsten reefs consist of greisen composed chiefly of a soft greenish-yellow mica, or of mica, fluorspar, topaz, and secondary feldspar. The greisen has been formed by the action of vapors on a porphyry or aplite (fine-textured white granite free from hornblende and mica). With the greisen is a variable amount of feldspar, chlorite, mica, fluorspar, topaz, tourmaline, wolframite scheelite, galena (rather rare), and pyrrhotite.

No tungsten reefs have been found without the quartz, although it is quite conceivable that such exist.

The quartz strings expand into lenses exceeding 20 feet in width, and thus make low hillocks such as those at "The Ranche" homestead.

The reefs vary from 200 yards to about 1 mile in length.

With one exception the reefs examined strike east to west and dip north at angles varying between 30° and 55°. The reef on plot 4 strikes northwest to southeast and dips northeast at 53°.

The width of the reefs is, of course, variable, owing to the lenses of quartz. Apart from the quartz lenses, the width averaged 3 feet and is surprisingly constant.

At the Union Jack the intrusion exceeds 6 feet in width, but about a third of it consists of white aplite apparently ungreisenized. The richest deposit, on Tungsten Kopje, is a stockwork of similar "reefs" nowhere more than 1 foot thick.

The country rock is without signs of shearing or faulting between it and the reef. It appears, therefore, that the aplite was injected along master-joint planes and not in fissures caused by faulting.

Considerable magnetite and ilmenite are found in the placer concentrates. Wolframite has been found in masses of 157, 172, and 235 pounds. (The second specimen is in the Rhodesia Museum). "Groups of pale pinkish scheelite measuring 3 or 4 inches are to be found."

Scheelite and wolframite are commonly intergrown, but the scheelite was commonly thrown away by miners. Would suggest that the "reefs" are in "normal greisen," but somewhat of the character of gold quartz veins and seem to form a connecting link. The rock inclosing the "reef" is pyritized (pyrite and pyrrhotite) and the feldspars are sericitized. The residual deposits are richest within 300 feet of the "greisen" on this steeper ground and within 75 feet on the flat ground. They carry 2 pounds to 8 pounds of wolframite per ton, the scheelite being rejected. The estimate does not include large lumps of wolframite or fine wolframite and scheelite in rock. On the Lunar Block reef in 1916 1,600 pounds of wolframite were picked up by hand after being gone over once.

The coarse and medium concentrate is remarkably clean wolframite. The finest concentrate consists of wolframite and scheelite, with a certain amount of other minerals from the weathered rocks, including a trace of gold. The finest concentrate is rejected under existing circumstances, but on a larger scale of operations concentrating tables and magnetic separators may be expected to give profitable results.

RADIUM, URANIUM, AND VANADIUM.

By Frank L. Hess.

PRODUCTION.

In 1917 there were produced and shipped, sold, or reduced in the United States 33,404 short tons of uranium and vanadium ores carrying 103 tons of uranium oxide (U_3O_8), or 87.4 tons of uranium and 26.4 grams of radium. There was actually isolated 11.96 grams of radium (Ra) contained in salts, mostly, if not all, chloride. The vanadium contained in the carnotite ores and in the roscoelite-bearing sandstone mined in southwestern Colorado amounted to 484 tons. In 1916 the figures were: Ores, 20,300 tons containing 10 grams of radium, 33.7 tons uranium (77,600 pounds U_3O_8), and 460 tons of vanadium.

The uranium ore was mostly carnotite (hydrous potassium-uranium vanadate) largely from the west side of Montrose and Mesa counties, Colo., with a little from the La Sal Mountains in the adjoining part of Utah (Grand County). The ore also included some uvanite (hydrous uranium vanadate) from Temple Rock, Emery County, 45 miles southwest of Green River, Utah. Most of the ore was mined by the companies isolating radium salts or by their representatives, but a small part was produced by prospectors and others who sold their ore to the companies.

The following companies were engaged in the isolation of radium during the year:

Carnotite Reduction Co. (Dr. H. N. McCoy), 2600 Iglehart Court, Chicago, Ill.
Chemical Products Co., 616 Majestic Building, Denver, Colo.
Colorado Radium Co., P. O. Box 1316, Denver, Colo.
W. L. Cummings Chemical Co., Lansdowne, Pa.
Radium Luminous Materials Corporation, 55 Liberty Street, New York, N. Y.
Standard Chemical Co., Pittsburgh, Pa.

Of these by far the largest is the Standard Chemical Co. The Chemical Products Co., of Denver, started work during the year on the uvanite ores from Temple Mountain and had radium salts ready for crystallization. The United States Metals Reduction Co. shipped a carload of ore from its mine in the Dolores River valley, Utah, northeast of the La Sal Mountains, to an experimental plant at Cheswick, Pa. The Radium Co. of America did no work at its plant at Sellersville, Pa., during the year.

Vanadium was produced principally in this country by the Primos Chemical Co. at Vanadium (formerly Newmire), Colo., where the company operated its reduction plant on the roscoelite-bearing sandstone found along Bear and Fall creeks and San Miguel River. The vanadium is separated from the ore as hydrous ferric vanadate and shipped to the Eastern States for reduction to ferrovanadium. The company is the second largest producer of vanadium and is surpassed only by the American Vanadium Co., of Pittsburgh, which draws its ores from Minasragra, Peru.

Each of the radium companies saved vanadium oxide as a by-product, and toward the end of the year the demand became strong for all vanadium-bearing substances that might be used as a source of the metal. The vanadium saved by the radium companies comes in part from the carnotite itself, but practically all if not all the ores carry an excess of vanadium over that required for the carnotite present. Possibly a part of the excess vanadium is present as roscoelite, the vanadium-bearing mica; a part is present as hewettite or metahewettite (hydrous calcium vanadates), calciovolborthite (hydrous calcium copper vanadate), and other less well-known minerals.

Some work was done on vanadinite and related mineral deposits in the Southwest during the year. Some ore (psittacinite or mottramite, lead-copper vanadate) was reported shipped by the Christmas Consolidated Mining Co., from Goodsprings, Nev. Near Kelvin, Ariz., the United States Vanadium Co. did considerable work on a vanadinite-bearing claim and made arrangements to erect a mill in which a dry separation process was to be used.

The vanadium deposits of the Southwest are all in the oxidized portions of lead-bearing veins. The lead is usually accompanied by a number of other sulphides, particularly those of zinc and copper. Phosphorus and arsenic also generally accompany the veins so that in the oxidized portions not only lead vanadate (vanadinite) but vanadates of copper and zinc are also present. These are not present as separate minerals, but take the form of a combined vanadate of lead and zinc or of lead, zinc, and copper, and the proportion of the metals may vary considerably. The minerals may vary also by containing in whole or in part either phosphorus or arsenic in place of vanadium. Nearly all deposits contain wulfenite, the lead molybdate, and most of them contain a small quantity of tungsten. This probably does not occur as the lead tungstate (stolzite), but seems to be a component of the wulfenite. Stolzite may occur, but it is not at all common, and has rarely been recognized. The percentage of tungsten rarely, if ever, exceeds 2 per cent. The deposits are generally small, so that no single one now known is large enough to furnish ore for a plant of considerable size.

USES, DEMAND, AND TRADE.

The demand for radium had a considerable setback after the United States entered the war but soon increased greatly, though the purposes for which it was to be used were those with the minimum permanent value. The greatest demand for radium since early in 1916 has been for use in the illumination of watch faces. Many thousands of the cheapest watches, the life of which is ordinarily not more than two or three years, were thus equipped, and oddly enough the illumination of the more expensive watches has followed much more slowly. Gun sights, compass faces, and airplane dials of various kinds were also illuminated. From those articles the radium is not recoverable.

When used as an illuminant a radium salt is mixed with artificial zinc sulphide and a cementing material, such as amyl acetate ("banana oil"). The alpha rays (helium atoms) given off by the radium strike the particles of zinc sulphide and make them luminescent. The degree of luminescence depends on the quality of the zinc sulphide and on the quantity of radium present.

Radium has proved itself so valuable in the treatment of human disease in ways for which no acceptable substitute is known that every effort should be made to conserve it.

Experienced surgeons say that if radium were useful for nothing else, the relief from pain it gives in certain forms of cancer makes it worth its whole cost. Radium cures some tumors which before it was discovered were successfully treated only by severe operations, and it is otherwise so useful that it can not well be dispensed with. That it does not cure all cancers or all tumors is beside the mark. Its value is sufficiently proved without claiming for it universal application.

The uses for uranium have not grown much. Many attempts have been made to use uranium in steel either as a substitute for tungsten or otherwise, and a little high-speed steel containing uranium is manufactured. Uranium is used in a small way for coloring yellow glass, such as that used in automobile headlights, for chemical reagents, and in the coloring of pottery; but the uses are small and the sodium uranate or other compounds made by the radium manufacturers is mostly awaiting buyers.

The principal use of vanadium is still in steels, especially where resistance to repeated strains is desired, and in tool steels.

PRICES.

The price of radium was from $90 to $120 a milligram for the element contained in a salt, such as the chloride or bromide, in a material containing 50 per cent or more of the pure salt.

Prices for carnotite were nominal and a subject of individual bargaining but ran about $2.50 a pound for the U_3O_8, in ore carrying 2 per cent of U_3O_8, with a bonus for richer ore and a penalty for lower grades. Uranium in ferrouranium, carrying 30 to 40 per cent of uranium, was quoted at $7.50 a pound. Sodium uranate was quoted at $2 to $2.50 a pound.

Vanadium in ferrovanadium, carrying 35 to 50 per cent of vanadium, was sold for $2.50 to $5.50, the larger price being obtained for small lots near the end of the year. The National Radium Institute sold iron vanadate in November, 1917, at 61 cents a pound for the V_2O_5 contained; in December it sold similar material at 75 cents a pound.

IMPORTS.

Uranium salts and oxide, including some radium salts, imported for consumption, 1913–1917.

Year.	Value.	Year.	Value.
1913	$34,319	1916	$5,065
1914	63,055	1917	2,930
1915	17,288		

EXPORTS.

Although figures are not available, it is known that a considerable quantity of radium salts was exported during the year.

LITERATURE AND PATENTS.

Among the literature and patents issued during 1917 that have to do with radium, uranium, and vanadium are the following:

Electrical World, Uranium calcium arc lamp: Vol. 70, p. 1002, 1917. Abstract by C. G. Fink, Chem. Abstracts, vol. 12, p. 252, February 10, 1918.

Comments on a recent patent (United States patent No. 1235996) by W. R. Mott (Chem. Abstracts, vol. 11, p. 2641). Uranium in the electric arc probably gives more lines in the spectrum than any other known element. Uranium has the distinction of giving 50 per cent more photographic power when used in the arc than rare-earth fluorides or titanium oxide. When uranium is mixed with calcium fluoride in making up an arc-lamp electrode, it fully blends with the yellow rays of the fluoride to produce an intense snow-white light of extraordinary photographic power.

Griffiths, F. J., The rôle of chrome-vanadium in alloy steels: Am. Soc. Test. Materials Proc., vol. 17, pp. 11, 33–44, 55–57, 1917. Chem. Abstracts, vol. 12, p. 352, February 20, 1918.

Keeney, R. M., and Vogt, L. F., Uranium alloys: United States patents No. 1240054 and No. 1240055, September 11, 1917. Abstract from Chem. Abstracts, vol. 11, pp. 3233–3234, 1917.

Fluorspar is stated to be the best slag-forming material for use in making ferrouranium alloys containing a high per cent of uranium. A charge for the production of ferrouranium is formed of steel turnings 10, uranium oxide 7.5, coke 6, and calcium fluoride 8 parts. At least 76 per cent of the uranium in this charge will be contained in the finished alloy and 100 pounds of the charge will produce approximately 40 pounds of ferrouranium, and by resmelting the residue approximately 85 per cent of the uranium may be alloyed with the steel and about 45 pounds of ferrouranium thus obtained. The ferrouranium produced has the composition uranium 29.2, carbon 5.12, silicon 2.68, and iron 63 per cent. If finely divided nickel is substituted for steel turnings in the specified charge, and alloy of otherwise similar composition containing 63 per cent nickel is produced in the same manner.

Kithil, K. L., and Davis, J. A., Mining and concentration of carnotite ores: Bur. Mines Bull. 103, 83 pp., 1917. Abstract by F. W. Smither, Chem. Abstracts, vol. 12, p. 1451, 1918.

A detailed account, with numerous illustrations, tables, flow sheets, etc., of the methods used in mining and concentrating the carnotite treated at Denver under a cooperative agreement with the National Radium Institute. The matter is presented in four chapters bearing the captions (1) The mining of carnotite ores by the National Radium Institute; (2) Grinding and sampling of shipping ore before chemical treatment; (3) Concentration of milling ore; (4) Costs of production.

Norris, G. L., The rôle of vanadium in alloy steels: Am. Soc. Test. Materials Proc., vol. 17, pp. 11, 33–44, 55–57, 1917. Iron Age, vol. 100, pp. 134–137, 1917. Abstract by W. T. Hall, Chem. Abstracts, vol. 11, p. 2573, September 20, 1917.

The remarkable effects of vanadium in steel are not due, as many have supposed, to the action of this element as deoxidizer and scavenger, but rather to the actual beneficial effect of the vanadium that remains in the steel. A few hundredths of 1 per cent of vanadium combined with ferrite appears to increase the strength, toughness, hardness, and resistance to abrasion. Nearly all the vanadium in steel, however, is present in the pearlite as a compound carbide of vanadium, iron, and other metals present.

Parsons, C. L., For the preparation of uranium oxides: United States patent No. 1224013, April 24, 1917.

Dedicated to the American people.

Parsons, C. L., For purifying compounds of uranium: United States patent No. 1224014, April 24, 1917.

Dedicated to the American people.

Plum, H. M., Extraction and separation of the radioactive constituents of carnotite: Mon. Sci., vol. 7, pp. 270–274, 1917. Abstract by G. L. Wendt, Chem. Abstracts, vol. 12, p. 648, 1918.

A critical review of the various commercial methods in use. Boiling with soda solution is the method recommended, and detailed directions are given for the separation of radium, polonium, radioactive lead, ionium, and actinium.

Rollason, A., Refining metals and alloys: British patent No. 110860, March 2, 1917. Abstract, Chem. Abstracts, vol. 12, p. 470, March 10, 1918.

Uranium is used for removing oxygen from molten metals and alloys and increasing their density. The uranium is used either in the solid or molten state, preferably in the proportion of 1–1.5 per cent and combines with the oxygen without combining with the metal treated.

Schmidt, C., Device for viewing radioactive substances: United States patent No. 1242377, October 9, 1917.

Radioactive salt preparations: Soc. anon. de traitements chimiques. French patent No. 482894, May 2, 1917. Abstract, Chem. Abstracts, vol. 12, p. 117, 1917.

The radioactive salts are intimately mixed with certain substances such as collodion, enamel, etc.; the liquid mass is poured into the desired forms and allowed to cool.

Stockholms Dagblad (Sweden), Our vanadium requirements secured: Issue of November 7, 1917.

A company consisting of Uddeholms Co., the Swedish Credit Co., and a Mr. Nathorst, has applied for concession to work the vanadium-bearing coal [This "coal" is usually referred to as culm and is possibly asphaltic. It is not coal in the sense in which the word is usually used. F. L. H.] strata on Billingen, Skaraborg Län. According to samples taken, the coal is of excellent quality, fully as good as the best English coal, but the vanadium contained is of greater value than the coal itself. This precious metal has heretofore been imported from America. It is on the market as ferrovanadium, which is of the greatest importance in the manufacture of the best grade of steel. It seems possible that all the needs for ferrovanadium are secured, so that we shall be independent of import from abroad for our steel manufacture. Even the export of vanadium is contemplated.

The occurrence of coal in Västergotland has been known for several years; that it carried vanadium was discovered as early as 1907 by State Geologist Dr. H. Hedstrom through investigations carried on by him in the vicinity of Tidaholm. However, the coal strata there were thin.

In 1914 Baron Essen asked for a concession to mine these, but no work was done. That the strata now to be worked carried vanadium was discovered last year (1916). As far as is now known the quantity of coal that could be taken out might reach 10,000 tons a year. The coal beds are only 0.1 to 0.2 of a meter in thickness. How much of the area may carry coal is not known, but it is intended to begin extensive surveys and borings. The coal is of very fine quality, much better than the coal from the province of Skane, and contains only 1 per cent of ash, against 4 per cent to 8 per cent in that from Skane. However, whenever the coal does not contain vanadium the mining will hardly be of any importance. The quantity of coal that is expected to be mined at present is, of course, of practically no importance, although it is not to be despised under the present conditions of coal shortage. Vanadium is naturally the important element. The ash left in the burning of the coal contains 40 to 50 per cent vanadic acid. One should therefore obtain about 2 kilograms of vanadium per ton of coal, or altogether about 20 tons of vanadium a year, as far as we can now know. So far as at present can be judged, working these deposits will be profitable even should they be no more extensive than they are now known to be, for the price of vanadium is at present abnormally high.

Viol, C. H., and **Kammer, G. D.**, The application of radium in warfare: Am. Electrochem. Soc. Trans., vol. 32, pp. 133–140, 1917. Chem. Abstracts, vol. 12, p. 114, 1917.

The chief uses are in therapy and luminous paints, especially for the dials of airplane instruments. The luminosity, which is due to the bombardment of zinc sulphide by X-rays, depends on the quality of the sulphide and the proportion of radium used in the paint. Crystalline hexagonal zinc sulphide prepared by a special method (not described) and with 0.215 milligrams of radium per gram of mixture is stated to give the best results. Other commercial mixtures contain 0.025 to 0.400 milligrams per gram. The zinc sulphide has apparently a definite capacity of total light emission, since the rate of decay of luminescence is proportionate to the amount of radium content and to the initial intensity of the light. Paints of suitable luminosity for many purposes but of shorter life can be made from cheaper radium substitutes, as mesothorium or radiothorium.

INDEX.

A. Page.
Abrasive bauxite 9
Adirondack district, iron ore 561-563
Africa, antimony 659
  chromite 42
  copper 726, 796
  gold 613
  iron ore 579, 583
  lead 883
  manganese ore 674, 686
  quicksilver 399
    exports to 382
  silver 615
  tin 69
  tungsten 934
  zinc 873
Alabama, bauxite 1, 3-4
  cooperation 25a
  alloys 598
  gold 56, 605, 619, 627, 634
  gold, silver, copper, lead, and zinc (mines report) 56-57
  iron ore 560-561, 567-568, 585
  manganese ore 669-671, 682
  pig iron 586-587, 588
  silver 56, 605, 619, 639
  value of mineral products 46a, 48a
Alaska, antimony 657
  chromite 38
  copper 132, 136, 725, 738-740, 742, 746-747
  gold 132, 605, 619, 621, 634, 642, 646
  gold, silver, copper, and lead (mines report) by G. C. Martin 18a, 131-145
  lead 132, 137, 883, 888
  platinum 13
  quicksilver 385, 399-400, 404
  silver 132, 605, 619, 622, 629, 642, 646
  tin 63-64
  tungsten 932-933, 935
  value of mineral products 46a, 48a
Algeria, iron ore 583
  quicksilver 399
Alum 7-8
  imports 8
Aluminum 5-9
  (*See also* Bauxite and aluminum.)
  Aluminum Co. of America 7
  bauxite abrasives 9
  British Aluminum Co 7
  consumption 6
  exports 35a, 6
  imports 35a, 6
  industry 7
  market 6
  prices 6
  production and consumption 5-6
Page.
Aluminum, refractories 9
  salts, production 7-8
    imports 35a, 8
    prices 8, 9
  secondary 6, 7, 312, 327-329
  summary 18a, 35a
  uses 7
  value 6
American Iron and Steel Institute, statistics of pig iron and steel 586, 601
Analyses, cobalt 903, 905
  stellite 903
Anthracite, summary 36a, 38a
  pig iron 593
Antimonial lead 656, 658, 884-885
  summary 30a
Antimony, by Edson S. Bastin 653-663
  diagram showing imports of antimony, 1914-1918 654
  diagram showing stocks of metallic antimony 654
  exports 661
  foreign sources 661-663
  imports 35a, 654, 659-661
    type metal 660
  ore 656, 658
  prices 654, 661
  production, mine 656-658
    smelter 658
      antimonial lead 658
  salts, imports 35a, 660
  secondary 312, 330, 659
  situation 653-655
  stocks 661
  summary 18a, 35a
  supply 656
  uses 655-656
    peace 655
    war 655
Argentina, antimony 659
  bismuth 31
  copper 726
  gold 613
  manganese 674
    imports 673
  pig iron, exports to 595
  quicksilver, exports 382
  silver 615
  tungsten 934
Arizona, copper 509, 725, 738-740, 742, 748-758
  gold 509, 605, 619, 622, 634, 637, 642, 646
  gold, silver, copper, lead, and zinc (mines report), by V. C. Heikes 18a, 509-556

Page.

- Arizona, lead 509,883,888
  - manganese ore 669–671,682
  - manganiferous ore 675
  - molybdenum 908–911
  - quicksilver 370,372,373,385,402,404–405
  - silver 509,605,619,622,639,642,646
  - tungsten ore 932–933,935–937
    - mills 945
  - value of mineral products 46a,49a
  - vanadium ore 956
  - zinc 509,862–863,864
- Arkansas, antimony 657
  - bauxite 1,3–5
  - iron ore 560–561,568
  - lead 77,79,883,888
  - manganese ore 669–671,683
  - rutile 929
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop 78–82
  - value of mineral products 46a,49a
  - zinc 77,79,856,862–863,864,866
- Arsenic, by J. B. Umpleby 23–27
  - condition of industry 23–24
  - development 24
  - imports 36a,25–26
  - outlook for 1918 27
  - prices 26–27
  - production 24–25
  - summary 18a,36a
- Asbestos, summary 19a,36a
- Ashland, shipments of iron ore 573
- Ashtabula, Ohio, receipts of iron ore 573
  - stocks of iron ore 575
- Asphalt summary 20a,36a
- Australasia, copper 795–796
  - gold 613
  - silver 615
- Australia, antimony 663
  - bismuth 31
  - chromic iron ore 42
  - copper 726,795
  - imports from 779
  - iron ore, production 583
  - manganese ore 674
    - imports 673
  - nickel, imports from 923
  - pig iron, exports to 595
    - imports from 594
  - platinum 13,14
  - quicksilver 399
    - exports to 382
  - tin 66,69
  - titanium (rutile) 930
  - zinc 873
- Austria, copper 726,793
  - exports to 780
  - molybdenum in ores 907
  - nickel 921
  - quicksilver 372,395
- Austria-Hungary, gold 613
  - iron ore 583
  - manganese ore 674
  - pig iron 595
    - exports to 595
    - imports from 594
  - quicksilver 372,395,396
  - silver 615

B. Page.

- Banca, tin 69
- Baraboo range, iron ore 571–572
- Barium compounds, imports 36a
- Barytes, summary 19a,36a
- Basic pig iron, production 591
- Bastin, E. S., paper on antimony 653–663
- Bauxite and aluminum, by James M. Hill 1–9
- Bauxite 1–5
  - abrasives 7,9
  - Alabama 1,3,4
  - Arkansas 1,3,4
  - brick 7,9
  - British and Dutch Guiana 3
  - consumption 1
  - exports 35a,1
  - Georgia 1,3,5
  - imports 35a,1
  - industry, by States 4–5
  - market 2
  - occurrence and character 3–4
  - prices 3
  - production by States 1
  - products 7,9
  - summary 18a,35a
  - Tennessee 1,3,5
  - uses 2
  - world's production 3
- Belgian Kongo, copper 796
  - silver 615
  - tin 69
- Belgium, arsenic 26
  - copper, exports to 780
  - iron ore 583
    - imports from 579
  - manganese ore, imports from 673
  - pig iron 595
    - exports to 595
    - imports from 594
- Beneficiated iron ore 583–585
- Bessemer iron ore, price 576
  - pig iron, production 591
  - steel 600–601
- Billiton, tin 69
- Birmingham district, iron ore 561–562
- Bismuth, by J. B. Umpleby 29–31
  - imports 35a,31
  - prices 29
  - production 29
  - summary 18a,35a
  - uses 29–31
- Blast furnaces, by States 591
- Bolivia, antimony 659,663
  - bismuth 31
  - copper 726
  - gold 613
  - silver 615
  - tin 66,69
  - tungsten 934,947
- Borax, summary 20a,36a
- Borneo, platinum 13,14
- Bosnia, manganese ore 674
- Boyne City, Mich., iron-ore receipts 574
- Brass, old, exports of 35a
  - imports 35a
  - remelted 312,313–317

Page.

- Brazil, gold 613
  - iron ore, exports to 580
  - manganese ore 666, 674, 687
    - imports from 666, 673
  - pig iron, exports to 595
  - platinum 15–16
  - quicksilver, exports to 382
  - silver 615
- Briquets (fuel) 20a
- British East Indies, gold 613
  - manganese ore, imports from 673
  - pig iron, imports from 594
  - quicksilver, exports to 382
- British Guiana, bauxite 3
  - gold 613
  - quicksilver, exports to 382
  - silver 615
- British Honduras, arsenic 26
- British India, gold 613
  - silver 615
- British Protected Malay States, tin 69
- British South Africa, chromic iron ore 42
  - quicksilver, exports to 382
  - tungsten ore, imports from 934
- Bromine, summary 20a
- Brown iron ore 560–562
- Buffalo, N. Y., receipts of Lake Superior iron ore 573
  - stocks of iron ore 575
- Burchard, Ernest F., paper on iron ore, pig iron, and steel 557–603
- Bureau of the Mint 606, 607
- Burma, tungsten 19a, 36a, 947
- Burrstones and millstones, summary 36a
- Butler, B. S., paper on copper 723–796
  - on silver, copper, lead, and zinc in Central States (Michigan) (mines report) 92–100

C.

- Cadmium, by C. E. Siebenthal 49–53
  - alloys 51
  - bibliography 53
  - exports 52
  - imports 52
  - introduction 49
  - prices 50, 52–53
  - production 49–50
    - in Germany 50
  - salts of 51
  - sources 50
  - summary 18a
  - uses 51
  - value 53
- Calcium chloride, summary 20a
- California, antimony 657, 658
  - chromic iron ore 38
  - copper 208, 725, 738–740, 742, 758–761
  - ferroalloys 598
  - gold 208, 605, 619, 623, 634, 642, 646
  - gold, silver, copper, lead, and zinc (mines report), by C. G. Yale 18a, 203–239
  - iron ore 560–561, 567, 568
  - lead 208, 883, 888
  - magnesium 149, 151
  - manganese ore 669–671, 683

Page.

- California, molybdenum 911–912
  - pig iron 586–587, 588
  - platinum 13, 17–19
  - quicksilver 370, 372, 373, 378, 385, 400–401, 405–414
  - silver 208, 605, 619, 623, 639, 642, 646
  - tungsten 932–933, 938–940
    - mills 945
  - value of mineral products 46a, 50a
  - zinc 208, 862–863, 864
- Canada, antimony 659
  - arsenic 26, 27
  - chromic iron ore 42
  - cobalt 905
  - copper 726, 785–788
    - exports to 780
    - imports from 779
  - gold 613
  - iron ore 583
    - exports to 580
    - imports from 579
  - lead 883, 893
  - magnesium 149, 151
  - manganese ore 674
    - imports from 673
  - nickel 917–919, 921–922, 923
    - imports from 923
  - pig iron 595
    - exports to 595
    - imports from 594
  - platinum 13, 14, 15, 20
  - quicksilver 400
    - exports to 382
  - rutile 930
  - silver 615
  - tin 63
  - zinc, electrolytic plants 865
    - ore, imports from 872–873
- Cape Colony, manganese ore 674
  - silver 615
- Carbonate iron ore 560–562
- Cement, summary 20a, 36a, 38a
- Central America, gold 613
  - lead 883
  - quicksilver 403
    - exports to 382
  - silver 615
- Central States, mine production 18a, 77
- Charcoal pig iron, production 593
- Chattanooga district, iron ore 562
- Chile, antimony 659
  - bismuth 31
  - copper 726, 789–792
    - imports from 779
  - gold 613
  - iron ore 583
    - exports to 580
    - imports from 579
  - manganese ore 674
    - imports from 673
  - pig iron, exports to 595
  - platinum 15
  - quicksilver, exports to 382
  - silver 615
  - tungsten ore 934
- China, antimony 659, 661

Page.

- China, gold ... 613
  - iron ore ... 583
  - manganese ore ... 686
  - pig iron, imports from ... 594
  - platinum ... 15
  - quicksilver ... 382, 398
  - silver ... 615
  - tin ... 66, 69
  - tungsten ore ... 934, 947
  - zinc ... 873
- Chosen (Korea), gold ... 613
  - iron ore, production of ... 583
  - quicksilver, exports to ... 382
  - silver ... 615
- Chromite, by J. S. Diller ... 37–47
  - composition and uses ... 37
  - consumption, needs for ... 42
  - ferrochromium ... 597–599
  - foreign sources ... 42–43
  - imports ... 35a, 42, 599
  - occurrence in North America ... 39
  - map of North America showing known deposits ... 39
  - ore ... 40–41, 44–47
    - concentration of ... 41
    - grade of domestic ... 40
    - owners of domestic deposits ... 44–47
  - prices ... 39–40, 42
  - production ... 38, 43
  - recommendations ... 43
  - salts ... 42
  - summary ... 18a, 35a
  - supplies ... 37–38
  - uses ... 37
- Clark, M. B., Summary of mineral production ... 27a–76a
  - (*See also* Mineral production of the United States.)
- Clay, summary ... 20a, 36a, 38a
- Clay products, summary ... 36a
- Cleveland, Ohio, receipts of iron ore ... 573
  - stocks of iron ore ... 575
- Coal, briquets, summary ... 20a
  - bunker ... 38a
  - summary ... 20a, 36a, 38a
- Cobalt, by Frank L. Hess ... 899–906
  - bibliography (patents) ... 905–906
  - consumption ... 904
  - general conditions ... 899
  - imports ... 35a, 904
  - mining operations ... 899–901
  - Haynes Stellite Co ... 899–901
  - Missouri Cobalt Co ... 901
  - prices ... 904
  - production ... 899, 901
    - Canadian ... 905
  - stellite ... 899–904
    - analyses ... 903
    - uses ... 901–904
  - substitute for platinum ... 904
  - summary ... 35a
- Coke, summary ... 20a, 37a, 38a
  - pig iron ... 593
- Colombia, antimony ... 659
  - gold ... 613
- Colombia, platinum ... 13, 14, 15, 17, 20
  - quicksilver, exports to ... 382
  - silver ... 615
- Colorado, copper ... 725, 738–740, 742, 761, 798
  - ferroalloys ... 598
  - gold ... 605, 619, 623, 634, 642, 646, 798
  - gold, silver, copper, lead, and zinc (mines report), by C. W. Henderson ... 18a, 797–853
  - iron ore ... 560–561, 568
  - lead ... 798, 883, 888
  - manganese ore ... 669–671, 683
  - manganiferous iron ore ... 669–671
    - silver ore ... 675
  - molybdenum ... 907, 912
  - pig iron ... 586–587, 588
  - quicksilver ... 385
  - radium ... 955
  - silver ... 605, 619, 624, 639, 642, 646, 798
  - tungsten ... 932–933, 941–943
    - mills ... 945
  - uranium ... 955
  - value of mineral products ... 46a, 51a
  - vanadium ... 955
  - zinc ... 798, 862–863, 864, 866
- Conneaut, Ohio, Lake Superior iron ore, receipts ... 573
  - stocks of iron ore ... 575
- Connecticut, iron ore ... 560–561, 568, 585
  - pig iron ... 586–587, 588
  - tungsten ... 932
  - value of mineral products ... 46a, 52a
- Copper, by B. S. Butler ... 723–796
  - casting copper ... 724, 775, 778
  - condition of industry ... 726
    - domestic ... 730
  - consumption ... 724, 726–730, 781–782
  - costs ... 785
  - electrolytic copper ... 724, 776, 778
  - exports ... 35a, 724, 730, 780–781
    - by countries ... 781
  - foreign production, review of ... 785–796
  - imports ... 35a, 724, 730, 779–780
    - by countries ... 779
  - introduction ... 723
  - labor efficiency ... 732–735
  - Lake copper ... 724, 776, 778
  - mine production ... 18a, 55, 77, 132, 136, 154, 161, 167, 208, 245, 253, 331, 457, 493, 509, 697, 721, 732–734, 741, 798
  - mines according to labor efficiency ... 733
  - ore ... 724
    - copper-bearing ... 742–746
    - gold in ... 742, 744
    - percentage of copper, by States ... 742
    - quantity, by States ... 742–745
    - silver in ... 742, 744
    - yield ... 724, 742, 744, 745
  - pig copper ... 775–776, 778
  - prices ... 724
    - average yearly ... 730, 731, 732
    - at New York in 1917 ... 783–784
    - 1850–1917 ... 79a
  - production ... 724, 730, 732
    - by countries ... 728
    - from 1845 to 1917 ... 735, 740
    - by principal districts ... 741

Page.

- Copper, production, by States 725, 739–742
  - production, total by States 740
    - costs 785
    - mine 724, 732–734, 741
    - mine returns 737–738
    - quantity of ore 724, 742
    - quantity and yield of ores 724, 742
    - refinery 724, 738, 775–776
    - refined copper, total 730, 778
    - review, by States 746–775
    - secondary 312–317, 730, 776–777, 778
    - smelter 724, 730, 735–737
    - smelter returns 738
    - smelting plants 736
    - sulphate 779
  - reduction plants in 1917 736–737
  - review of foreign production 785–796
  - stocks 779
  - summary 18a, 35a
    - of statistics 724
  - uses 782–783
  - value 724
    - in gold and silver, per ton 742, 744
  - world's production 724–730
- Copper-lead and copper-zinc ores 743–744
- Cornwall, tin 69
- Corundum and emery, summary 37a
- Costa Rica, manganese ore 674, 689
    - imports from 673
  - pig iron, exports to 595
  - quicksilver, exports to 382
- Crucible steel 601
- Cryolite, summary 20a, 37a
- Crystal Falls area, iron ore 578
- Cuba, chromic iron ore 42
  - copper 726, 788–789
    - imports from 779
  - gold 613
  - iron ore 581, 582, 583
    - imports from 579
  - manganese ore 674, 689
    - imports from 673
  - pig iron, exports to 595
    - imports from 594
  - quicksilver, exports to 382
- Cuyuna range, iron ore 571–572, 578
  - manganiferous iron ores 675
- Cyanides, consumption of 648–651

D.

- Delaware, value of mineral products 46a, 52a
- Denmark, pig iron, exports to 595
- Detroit, Mich., receipts of iron ore 573
- Diatomaceous (infusorial) earth, summary 37a
- Director of the Mint 606, 607
- Diller, J. S., paper on chromite 37–47
- District of Columbia, value of mineral products 46a, 52a
- Dominican Republic, quicksilver, exports to 382
- Duluth, shipments of iron ore 573
- Dunlop, J. P., paper on silver, copper, lead, and zinc in the Central States (mines reports) 73–92, 100–130
  - on gold and silver (general report) 605–651
  - on secondary metals 299–330
- Dutch East Indies, gold 613

Page.

- Dutch East Indies, platinum 15
  - quicksilver, exports to 382
  - silver 615
  - tin 66
- Dutch Guiana, bauxite 3
  - cadmium 52
  - gold 613

E.

- East Indies, quicksilver 398
- East Jordan, Mich., iron-ore receipts 574
- Eastern States, mine production 55
- Economic limits to domestic independence in minerals, by George Otis Smith 1a–6a
- Ecuador, gold 613
  - quicksilver, exports to 382
  - silver 615
  - tungsten ore 934
- Egypt, iron-ore imports from 579
  - silver 615
- Electric steel 600, 601
- Elk Rapids, Mich., iron-ore receipts 574
- Emery, summary 37a
- England, antimony 659
  - arsenic 26
  - bismuth 31
  - cadmium 50
  - chromite 42
  - copper 726, 780
  - iron ore, exports to 580
  - pig iron, exports to 595
    - imports from 594
  - platinum 15
  - quicksilver, exports to 382
  - tin 66
- Erie, Pa., receipts of Lake Superior iron ore 573
  - stocks of iron ore 575
- Escanaba, shipments of iron ore 573
- Evans, I. P., bibliography of quicksilver 425–455
- Exports, aluminum 35a, 6
  - abrasives 38a
  - antimony 661
  - asbestos 38a
  - asphalt 37a
  - bauxite 35a, 1
  - brass, old 35a
  - cadmium 52
  - cement 38a
  - clay 38a
  - coal 38a
  - coke 38a
  - copper 35a, 780–781
  - ferromanganese 36a
  - ferrosilicon 36a
  - ferrotungsten 36a
  - ferrovanadium 36a
  - fertilizers 38a
  - gasoline 38a
  - gold 610
  - graphite 38a
  - iron ore 36a, 570, 580–581
  - lead 36a, 894–895
  - lime 38a
  - magnesium 148

Page.

- Exports, marble and stone 39a
  - mica 38a
  - nickel 36a, 923
  - paints 38a
  - paraffin 38a
  - petroleum 38a
  - phosphate, crude 38a
  - pig iron 36a, 595
  - plaster 38a
  - platinum 36a
  - potash 38a
  - quicksilver 36a, 381–382
  - salt 38a
  - sand and gravel 38a
  - silver 610
  - slate 39a
  - soda 38a
  - steel 603
  - sulphur 39a
  - tin 36a
  - tungsten 36a, 934
  - zinc 36a, 873–875
    - foreign 875–876
    - oxide 874

F.

- Fairport, Ohio, receipts of Lake Superior iron ore 573
  - stocks of iron ore 575
- Federated Malay States, gold 613
  - tin 66, 69
- Feldspar, summary 20a
- Ferroalloys 596–599
  - exports 36a
  - imports 35a, 599
  - manufactures of, by States 598
  - prices 597, 598
  - shipments and value 596–597
  - summary 35a–36a
- Ferrocerium 597
- Ferrochromium 597–599
  - imports 599
  - summary 35a
- Ferromanganese 591, 597
  - (*See also* Manganese ore.)
  - imports 35a, 599
  - plants making ferromanganese 679
  - prices 598
  - production 597
  - summary 35a, 36a
- Ferromolybdenum 597–598
  - imports 599
- Ferrophosphorus 597–599
  - imports 599
  - summary 35a
- Ferrosilicon 591, 597–599
  - imports 599
  - summary 35a, 36a
- Ferrotitanium 597–599
  - imports 599
  - summary 35a
- Ferrotungsten 597–599
  - imports 599
  - summary 35a, 36a
- Ferrouranium 597

Page.

- Ferrovanadium 597
  - summary 36a
- Fertilizers, summary 37a, 38a
- Finland, gold 613
- Flint pebbles, summary 20a, 37a
- Florida, cooperation 25a
  - ilmenite 929
  - value of mineral products 46a, 53a
- Fluorspar, summary 20a, 37a
- Forge and foundry iron, production 591
- Formosa, gold 613
  - silver 615
- France, antimony 663
  - arsenic 26
  - bauxite 3
  - cadmium 52
  - copper, exports to 780
  - gold 613
  - iron ore 583
  - manganese ore 674
    - imports from 673
  - pig iron 595
    - exports to 595
    - imports from 594
  - platinum 15
  - quicksilver 395
    - exports to 382
  - silver 615
  - zinc 873
- French Africa, iron ore 579, 583
  - zinc ore 873
- French East Africa, silver 615
- French East Indies, zinc 873
- French Guiana, gold 613
  - quicksilver, exports to 382
- French Indo-China, gold 613
  - silver 615
- French Oceania, chromite 42
  - iron ore, imports from 579
  - nickel, imports from 923
- Fuller's earth, summary 37a

G.

- Garnet (abrasive), summary 20a
- Gary, Ind., iron-ore receipts 574
- Gas (artificial) and by-products 20a
- Gas (natural) 20a
- Gasoline, summary 37a, 38a
- Gems and precious stones, summary 20a, 37a
- Georgia, bauxite 1, 3–5
  - cooperation 25a
  - copper 56, 58, 725, 738, 742, 775
  - gold 56, 58, 605, 619, 627, 642, 646
  - gold, silver, copper, lead, and zinc (mines report) 57–58
  - iron ore 560–561, 567, 568, 585
  - manganese ore 669–671
  - pig iron 586–587
  - silver 56, 58, 605, 619, 639, 642, 646
  - value of mineral products 46a, 53a
- German Southwest Africa, tin 69
- Germany, arsenic 26
  - cadmium 50
    - imports from 50
  - copper 726, 793

Page.
Germany, copper, exports to ... 780
  copper, imports from ... 779
  gold ... 613
  iron ore ... 583
    imports ... 579
  lead, imports from ... 893
  manganese ore ... 674
    imports from ... 673
  nickel ... 921
  pig iron ... 595
    exports to ... 595
    imports from ... 594
  quicksilver ... 395
  silver ... 615
  tin ... 69
Gerry, C. N., paper on gold, silver, copper, lead, and zinc in Idaho (mines report) ... 457-492
  in Washington (mines report) ... 493-507
Glass sand, summary ... 21a, 32a
Gogebic range, iron ore ... 571-572, 578
Gold and silver, paper by H. D. McCaskey and John P. Dunlop ... 605-651
  acknowledgments ... 605
  copper ores ... 632, 634, 638, 639, 640, 641
  copper-lead ores ... 634, 639, 641
  curves showing production and value of gold and silver and price per fine ounce of silver in the United States, 1871-1917 ... 609
  Director of the Mint ... 606, 607
  distribution, by States and sources, of production of gold in 1917 ... 633-639
    production of silver in 1917 ... 639-642
    by methods of treatment ... 642-645
      percentage of output by processes ... 645
      consumption of cyanides ... 648-651
      of quicksilver ... 648
  domestic supply of gold and silver ... 610
  dry and siliceous ores ... 632, 634, 636, 638, 639, 640, 641
  exports ... 610
  gold and silver in the war ... 616-617
  imports ... 610
  increase and decrease, by States ... 606, 619
  larger producers of gold ... 620
    of silver ... 621
  lead ores ... 632, 634, 639, 641
  lead-zinc ores ... 632, 634, 639, 641
  mines report ... 18a, 618-651
    comparison of mint report and mines report ... 618-619
    consumption of cyanides and quicksilver ... 648-651
    method of collecting statistics ... 618-619
  mine production of gold and silver ... 55, 132, 154, 161, 167, 208, 245, 253, 331, 457, 493, 509, 619, 697, 721, 798
  number of producing mines ... 629-631
    by States and Territories ... 621-629
    ore, production, classification, and average value of ... 631-633
      quantity of ... 637-638
    placers ... 634, 640, 641, 645
      dredges ... 635-636

Page.
Gold and silver, prices of silver ... 607
  prices of silver, 1850-1917 ... 79a
  production, by States, in 1917 ... 605, 619
    at mills ... 645-648
    since 1792 ... 607
    since 1880 ... 608
  summary ... 30a
  units of measurement ... 619
  value, average per ton of ore ... 632
  world's production of gold ... 611-614
    decline in ... 611
    value ... 611, 613
    of silver, 1860-1917 ... 614
      by countries, 1905-1917 ... 615
    zinc ores ... 632, 634, 639, 641
Gold, silver, copper, lead, and zinc in Eastern States (mines report), by J. M. Hill ... 18a, 55-62
  mine production ... 55-57
  review by States ... 57-62
    Alabama ... 517
    Georgia ... 57-58
    Maine ... 58
    Maryland ... 58
    New Hampshire ... 58
    New Jersey ... 59
    New York ... 59
    North Carolina ... 59-60
    Pennsylvania ... 60
    South Carolina ... 60
    Tennessee ... 60-61
    Vermont ... 61
    Virginia ... 61-62
Gold, silver, copper, lead, and zinc in Western States (mines reports):
  Alaska, by G. C. Martin ... 18a, 131-145
  Arizona, by V. C. Heikes ... 18a, 509-556
  California, by C. G. Yale ... 18a, 203-241
  Colorado, by C. W. Henderson ... 18a, 797-853
  Idaho, by C. N. Gerry ... 18a, 457-492
  Montana, by V. C. Heikes ... 18a, 331-366
  Nevada, by V. C. Heikes ... 18a, 253-298
  New Mexico, by C. W. Henderson. 18a, 697-720
  Oregon, by C. G. Yale ... 18a, 243-252
  South Dakota, by C. W. Henderson ... 18a, 153-160
  Texas, by C. W. Henderson ... 18a, 721-722
  Utah, by V. C. Heikes ... 19a, 167-202
  Washington, by C. N. Gerry ... 19a, 493-507
  Wyoming, by C. W. Henderson ... 19a, 161-165
Gold Coast, manganese ore ... 674, 686
Granite, summary ... 37a
Graphite, summary ... 20a, 37a, 38a
Great Britain, antimony ... 659
  arsenic ... 26
  bauxite ... 3
  bismuth ... 31
  chromic iron ore ... 42
  copper exports to ... 780
    imports from ... 779
  gold ... 613
  iron ore ... 583
    exports to ... 580
    imports from ... 579
  lead, imports from ... 893

Great Britain—Continued. Page.

- pig iron, 595
- platinum, 15
- quicksilver, exports to, 382
- silver, 615

- Greece, chromic iron ore, 42
  - iron ore, 583
    - imports from, 579
  - manganese ore, 674
    - imports from, 673
  - nickel, 921
  - pig iron, exports to, 595
  - silver, 615
- Grindstones, summary, 37a, 39a
- Guatemala, quicksilver, exports to, 382
  - chromic iron ore, 42
- Guiana, bauxite, 3
  - gold, 613
  - silver, 615
- Gypsum, summary, 21a, 37a

H.

- Haynes Stellite Co., 899, 901–904
- Heikes, V. C., gold, silver, copper, lead, and zinc in Arizona (mines report), 509–556
  - Montana (mines report), 331–366
  - Nevada (mines report), 253–298
  - Utah (mines report), 167–202
- Hematite, 560–562
- Henderson, Charles W., gold, silver, copper, lead, and zinc in Colorado (mines report), 797–853
  - New Mexico (mines report), 607–720
  - South Dakota (mines report), 153–160
  - Texas (mines report), 721–722
  - Wyoming (mines report), 161–165
- Herzegovina, manganese ore, 674
- Hess, Frank L., paper on cobalt, 899–906
  - molybdenum, 907–915
  - nickel, 917–927
  - radium, uranium, and vanadium, 955–959
  - titanium, 929–930
  - tungsten, 931–954
- Hewett, D. F., paper on manganese and manganiferous ores, 665–696
- High-alumina refractories, 9
- Hill, J. M., paper on bauxite and aluminum, 1–9
  - gold, silver, copper, lead, and zinc in Eastern States (mines reports), 55–62
  - platinum and allied metals, 11–21
- Honduras, antimony, 659
  - manganese ore, 690
  - quicksilver, exports to, 382
- Hones, oilstones, summary, 37a
- Hongkong, antimony, 659
  - pig iron, imports from, 594
  - quicksilver, exports to, 382
  - tin, 66
  - tungsten ore, 934
  - zinc, 873
- Hungary, iron ore, 583
  - manganese ore, 674
  - quicksilver, 372, 395
- Huron, Ohio, receipts of iron ore, 573
  - stocks of iron ore, 575

I. Page.

- Ichthyol, summary, 37a
- Idaho, antimony, 657
  - cobalt, 899–901
  - copper, 457, 725, 738–740, 742, 761
  - gold, 457, 605, 619, 624, 634, 637, 642, 646
  - gold, silver, copper, lead, and zinc (mines report), by C. N. Gerry, 18a, 457–492
  - lead, 457, 883, 888
  - quicksilver, 370, 372, 373, 385, 401, 414–415
  - silver, 457, 605, 619, 624, 639, 642, 646
  - tungsten, 932, 943
    - mills, 945
  - value of mineral products, 46a, 54a
  - zinc, 457, 862–863, 864
- Illinois, cooperation, 25a
  - ferroalloys, 598
  - lead, 77, 83, 883, 888
  - pig iron, 586–587, 588
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop, 82–86
  - silver, 77, 83, 605, 619, 625, 639
  - steel, 600
  - value of mineral products, 46a, 54a
  - zinc, 77, 83, 856, 862–863, 864, 866
- Ilmenite, 73a, 929, 930
- Imports, aluminum, 35a, 6
    - salts, 35a, 8
  - antimony, 35a, 654, 659–661
    - salts, 35a, 660
  - arsenic sulphides, 36a, 25–26
  - arsenious oxide, 36a
  - asbestos, 36a
  - asphalt, 36a
  - barium compounds, 36a
  - barytes, 36a
  - bauxite, 35a, 1
  - bismuth, 35a, 31
  - borax, 36a
  - brass, old, 35a
  - burrstones, 36a
  - cadmium, 52
  - cement, 36a
  - cerium, 35a
  - chalk, 36a
  - chromite, 35a, 42
  - chromium salts, 35a, 42
  - clay, 36a
  - clay products, 36a
  - coal, 36a
  - cobalt oxide, 35a, 904
  - coke, 37a
  - copper, 35a, 779–780
  - corundum, 37a
  - cryolite, 37a
  - diatomaceous (infusorial) earth, rotten stone, and tripoli, 37a
  - emery, 37a
  - explosives, 37a
  - ferroalloys, 35a, 599
  - ferrochromium, 35a, 599
  - ferromanganese, 35a, 599, 666
  - ferromolybdenum, 599
  - ferrophosphorus, 599

Page.

- Imports, ferrosilicon 35a, 599
  - ferrotitanium 35a, 599
  - ferrotungsten 35a, 599
  - ferrovanadium 36a
  - fertilizers 37a
  - flint pebbles 37a
  - fluorspar 37a
  - fuller's earth 37a
  - gasoline 37a
  - gems and precious stones 37a
  - gold 610
  - granite 37a
  - graphite 37a
  - grindstones 37a
  - guano 37a
  - gypsum 37a
  - hones, whetstones 37a
  - ichthyol 37a
  - iridium 35a, 15
  - iron ore 35a, 570, 579–580
  - kainite 37a
  - kaolin 36a
  - lead 35a, 892–894
    - pigments 37a, 894
  - lime 37a
  - lithographic stone 37a
  - magnesia 37a
  - magnesite 37a
  - magnesium 148
  - manganese ore 35a, 666
    - by countries 673
  - manure salts 37a
  - marble and stone 37a
  - mica 37a
  - mineral salts 37a
  - mineral waters 37a
  - molybdenum 599
  - monazite and thorium oxide 37a
  - nickel 35a, 922–923
  - ocher 37a
  - oilstones 37a
  - osmium 35a, 15
  - osmiridium 35a, 15
  - ozokerite 37a
  - palladium 35a, 15
  - paraffin 37a
  - peat 37a
  - petroleum 37a
  - phosphates 37a
  - pig iron 594
  - platinum 35a, 15
  - potassium chloride 37a
    - sulphate 37a
  - pottery 36a
  - pumice 37a
  - pyrite 37a
  - quicksilver 35a, 381, 382
  - radium salts 35a, 957
  - rhodium 35a
  - ruthenium 35a
  - salt 37a
  - sand and gravel 37a
  - selenium 37a
  - sheep dip 36a
  - sienna 37a

Page.

- Imports, silver 610
  - slate 37a
  - sodium nitrate 37a
  - spiegeleisen 35a, 599, 666
  - steel 602
  - strontium salts 37a
  - sulphur 37a
  - talc 37a
  - thorium nitrate 37a
  - tin 36a, 66–67
  - titanium 35a
  - tungsten 35a, 933, 934
  - type metal 35a, 660
  - umber 37a
  - uranium salts 35a, 957
  - venetian red 37a
  - zinc 35a, 869–873
    - brass, old 35a, 871
    - dust 35a, 871
    - ore 35a, 870, 872–873
    - oxide 37a, 871
- India, bauxite 3
  - gold 613
  - iron ore 583
  - mangnese ore 674, 687
    - imports from 666, 673
  - silver 615
  - tin 69
  - zinc 873
- Indiana, cobalt 899, 901–904
  - pig iron 586–587, 588
  - steel 600
  - stellite 899, 901–904
  - value of mineral products 46a, 55a
  - zinc smelter 866
- Indiana Harbor, Ind., iron-ore receipts 574
- Indo-China, gold 613
  - silver 615
  - tin 69
  - zinc 873
- Infusorial earth. (*See* Diatomaceous earth.)
- International control of minerals, by C. K. Leith 7a–16a
  - changes brought about by the war 8a–9a
  - general conclusions as to the international control of minerals from the standpoint of the United States 12a–16a
  - international control as a war measure 9a
  - movements of minerals under pre-war conditions 8a
  - position of the United States 11a–12a
  - possibility of post-war international control 9a–10a
  - specific plans of international control 10a
  - world movement of minerals 7a
- Iowa, cooperation 25a
  - ferroalloys 598
  - iron ore 560–566, 567, 568, 585
  - lead 77, 87, 883, 888
  - pig iron 586
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop 86–87
- Iowa, value of mineral products 46a, 55a
  - zinc 77, 87, [illegible]3, 864

Page.

- Iridium, 35a, 11-12, 14, 15, 16
  - (*See also* Platinum and allied metals.)
  - summary, 19a, 35a
  - uses, 11-12
- Iridosmine, 19a, 35a, 11, 14, 15, 16
- Iron. (*See* Pig iron and steel.)
- Iron ore, 35a
- Iron ore, pig iron, and steel, by Ernest F. Burchard, 557-603
  - apparent annual consumption compared with production of pig iron, 569-570
  - Baraboo area, 571-572
  - beneficiated ore, statistics, 583-585
  - Bessemer ores, prices, 576
  - Cuba, shipments from, 581-582
  - curve showing production of iron ore, pig iron, and steel, 1870-1917, 559
  - exports, 36a, 570, 580-581
  - foreign trade, 579-581
  - imports, by countries, 35a, 570, 579-580
  - introduction, 557
  - iron-ore industry, Lake Superior district, 562, 571-578
    - beneficiation of ores, 583-585
    - mining developments, 576-578
      - labor conditions, 577
        - wages, 577
    - reserves in Michigan and Minnesota, 578
    - prices, 575-576
    - production by ranges, 571-572
    - ranges, 571
    - shipments, by ports, 572-573
      - 1854-1917, 574
  - ore mined and shipped in 1917, 558-567
    - mined by mining districts, 562-563
      - by States, 560-561
      - by varieties, 561-563
    - mined and shipped, by States, 558-560
    - shipments by States, 560
      - increase or decrease, 560
        - percentage of, 560
  - percentage of pig iron to iron ore, 570
  - price per ton, by States and varieties, 567-568, 575-576
  - principal iron-ore mines, 564-567
  - production in principal countries, 582-583
    - total output in the United States, 1810-1817, 563
    - comparative output of iron ore, pig iron, and steel, 559
  - receipts at Lake Erie ports, 573
    - at Lake Michigan ports, 574
  - stocks at Lake Erie ports, 570, 575
    - at mines, by States, 567, 570
  - summary, 19a, 35a, 36a
  - value, by States, 560
  - world's production, 583
  - zinc residuum, 570
- Iron Ridge area, iron ore, 571-572
- Iron River area, iron ore, 578
- Italy, bauxite, 3
  - cadmium, 52
  - copper, 726, 793
    - exports to, 780
  - gold, 613
  - iron ore, 583

Page.

- Italy, manganese ore, 674
  - pig iron, 595
    - exports to, 595
    - imports from, 594
  - quicksilver, 372, 396-397
  - silver, 615
  - tin, 69
  - zinc, 873

J.

- Jamaica, quicksilver, exports to, 382
- Japan, antimony, 659, 662
  - arsenic, 26
  - chromic iron ore, 42
  - copper, 726, 795
    - imports from, 779
  - gold, 613
  - iron ore, 583
  - manganese ore, 674
    - imports from, 673
  - pig iron, exports to, 595
    - imports from, 594
  - quicksilver, 398
    - exports to, 382
  - silver, 615
  - tin, 69
  - tungsten, 934
  - zinc, 873

K.

- Kansas, lead, 77, 87, 883, 888
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop, 87-90
  - value of mineral products, 46a, 56a
  - zinc, 77, 87, 856, 862-863, 864, 866
- Kaolin, imports, summary, 36a
- Katanga, copper, 796
- Kentucky, ferroalloys, 598
  - lead, 77, 91, 883, 888
  - pig iron, 586-587, 588
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop, 90-92
  - silver, 625
  - value of mineral products, 46a, 56a
  - zinc, 77, 91, 862-863
- Knopf, Adolph, paper on tin, 63-72
- Kongo, Belgian, copper, 796
  - silver, 615
- Korea (Chosen), gold, 613
  - iron ore, 583
  - quicksilver exports to, 382
  - silver, 615

L.

- Labrador, antimony, 659
  - iron ore, imports from, 579
  - pig iron, imports from, 594
- Lake Erie ports, iron ore, 573, 575
- Lake Michigan ports, iron ore, 574
- Lake Superior, copper, 71-80, 667-668, 695, 716
  - iron ore, 562, 571-578
    - prices, 575-576
    - production by ranges, 571
      - 1854-1917, 572

Page.

Lake Superior, iron ore, ranges 571-572
  iron ore, shipments and receipts 572-574
    stocks 575
  manganiferous iron ore 34-36
  mining district 562, 571-578
Lead, by C. E. Siebenthal 881-897
  antimonial 881, 884-885
  consumption 881, 895-896
  desilverized 881, 882, 884
  exports, domestic 36a, 894-895
    foreign 895
  from foreign ore and base bullion 882
  imports 35a, 893-894
    by classes 894
    by countries 893
    warehouse transactions 891-892
  introduction 881
  mine production 18a, 55, 77, 132, 154, 167, 208, 245, 253, 331, 457, 493, 509, 697, 721, 798, 887-889
    by districts 889
    percentage by districts 889
  mined in 1917, by States and ores 888
  ore 888-889
  percentage of lead by ores 888
  pigments 885-886
    from ore 865-886
    from pig lead 886
    summary 37a
  prices 882, 897
    at New York in 1917 882
    curves, showing weekly price 896
    1850-1917 79a
  production 882-889
    1720-1917 882
    by States 882-883
    from domestic ore 881, 882
    of refined or pig 881
    of soft lead 881, 882, 884
  secondary 312, 317-319, 881, 886
  smelters 890-891
    changes 891
  source of lead, by ore and States 883
  summary 19a, 35a, 36a
    of statistics 881
  trade conditions 891
  type metal, imports 35a
  value 881, 882, 897
  warehouse transactions 891-892
  world's production 891
Lead pigments 37a, 885-886
Leaded zinc oxide 859, 886
Leith, C. K., international control of minerals 7a-16a
Lime, summary 21a, 37a, 38a
Litharge 886, 894
Lithium minerals, summary 21a
Lithopone 859
Lorain, Ohio, receipts of iron ore 573
  stocks of iron ore 575
Louisiana, value of mineral products 46a, 57a
Low-phosphorus iron, production 591
Luxemburg, iron-ore production 583

M.

Madagascar, silver 615
Magnesite, summary 21a, 37a

Page.

Magnesium, paper on, by Ralph W. Stone 147-151
  character 149
  demand and supply 151
  exports 148
  imports 148
  prices 148
  producers 148
  production 147
  source 149
  summary 37a
  supply raw material 151
  uses 149-151
Magnetite ore 560-562
Maine, copper 56, 58, 725, 738, 742
  gold, silver, copper, lead, and zinc (mines report) 56, 58
  value of mineral products 46a, 57a
Malay States, gold 613
  tin 66, 69
Malleable pig iron 591
Manganese and manganiferous ores, by D. F. Hewett 665-696
  bibliography 691-696
  ferromanganese 591, 597, 666, 678-682
    consumption per ton of steel 682
    imports 35a, 599, 666, 681
    prices 598, 681
  ferruginous manganese ores 668, 674-675
  imports 35a, 666
    by countries 666, 673
  introduction 665
  notes on domestic deposits 682-686
    foreign deposits 686-690
  ore 666, 667-669
  prices 676-678
  production 591, 597, 666, 669-671, 672
    by countries 674
    by States 669-671
    1838-1917 672
    1890-1917 666
  shipments 669-671
  sources of manganese 666
    list of principal minerals 667
  spiegeleisen 591, 597, 666, 678-682
    consumption per ton of steel 682
    imports 599, 666, 681
    prices 598, 681
  steel 666
  summary 19a, 35a
  value of ores 669-671, 675-678
  world's production 673-674
Manganiferous ores 668, 674, 678
  iron ore 668
  manganiferous zinc residuum 669, 678
  production by States 675
    silver ore 675
    zinc residuum 570, 669, 678
  silver ores 669, 675
  summary 19a, 35a
Marble and stone, summary 22a, 37a, 39a
Marquette, shipment of iron ore 573
Marquette range, iron ore 571-572, 578
Martin, G. C., paper on gold, silver, copper, and lead in Alaska (mines report) 131-145

Page.

- Maryland, chromite ... 38
  - cooperation ... 25a
  - copper ... 56, 58, 725, 738, 743
  - ferroalloys ... 598
  - gold ... 56, 619, 627
  - gold, silver, copper, lead, and zinc (mines report) ... 56, 58
  - iron ore ... 560–561, 567, 568, 585
  - pig iron ... 586–587, 588
  - silver ... 56, 58, 619, 627
  - value of mineral products ... 46a, 58a
- Massachusetts, iron ore ... 560–561, 567, 568, 585
  - pig iron ... 586–587, 588
  - value of mineral products ... 46a, 58a
- McCaskey, H. D., paper (with John P. Dunlop) on gold and silver in United States ... 605–651
  - mineral production of the United States in 1917—a summary ... 17a–76a
  - prefatory note to the general and mines reports on gold, silver, copper, lead, and zinc in 1917 ... 77a
- Menominee range, iron ore ... 571–572, 578
- Mercury. (*See* Quicksilver.)
- Mesabi range, iron ore ... 571–572, 578
- Mexico, antimony ... 659, 662–663
  - arsenic ... 24, 26, 27
  - copper ... 726, 788
    - imports from ... 779
  - gold ... 613
  - iron ore, exports to ... 580
  - lead ... 883
    - imports from ... 893
  - manganese ore ... 674
    - imports ... 672
  - molybdenum in ores ... 907
  - pig iron, exports to ... 595
  - platinum ... 15
  - quicksilver ... 372, 402–403
    - exports to ... 382
  - rutile ... 930
  - silver ... 615
  - tungsten ... 934
  - zinc ore, imports from ... 872, 873
- Mica, summary ... 21a, 37a, 38a
- Michigan, cooperation ... 25a
  - copper ... 77, 93, 725, 738–740, 742, 761–766
  - iron ore ... 560–561, 567, 568, 585
  - magnesium ... 149
  - manganese ore ... 671, 683
  - pig iron ... 586–587, 588
  - silver ... 77, 93, 605, 619, 625
  - silver, copper, lead, and zinc (mines report), by B. S. Butler ... 92–100
  - value of mineral products ... 46a, 59a
- Millstones and burrstones, summary ... 36a
- Milwaukee, Wis., iron-ore receipts ... 574
- Mineral paints, summary ... 21a, 37a
- Mineral production of the United States in 1917—a summary, by H. D. McCaskey and M. B. Clark ... 17a–76a
  - acknowledgments ... 23a
- Mineral production, cooperation with State geological surveys ... 25a–26a

Page.

- Mineral production, etc.—Continued.
  - curves showing value of the mineral production, 1880–1917 ... 34a
  - imports and exports, 1916–17 ... 35a–39a
  - increase or decrease ... 30a
  - introduction ... 17a
  - mineral production, 1880–1917 ... 33a
  - mineral products, 1917, in order of value ... 40a–41a
  - Mineral Resources volumes, 1908–1917, containing full reviews ... 18a–22a
  - organization ... 23a–25a
  - production, by States, 1916–17 ... 40a–76a
    - of principal metals, fuels, structural materials ... 42a–43a
  - rank of States in value of production ... 44a–45a
  - scope of report ... 17a
  - summary ... 27a–76a
    - general remarks ... 27a–29a
    - metallic products ... 30a, 33a
    - nonmetallic products ... 30a–32a, 33a
  - value assigned to production ... 22a–23a
    - by States ... 46a–76a
  - total ... 32a, 33a
- Mines reports, production of copper ... 18a, 55, 56, 77, 132, 136, 154, 161, 167, 208, 245, 253, 331, 457, 493, 509, 697, 721, 798
  - gold ... 18a, 55, 56, 132, 154, 208, 245, 253, 331, 457, 493, 509, 619, 697, 721, 798
  - lead ... 18a, 55, 57, 77, 132, 154, 167, 208, 245, 253, 331, 457, 493, 509, 697, 721, 798, 888
  - silver ... 18a, 55, 56, 77, 132, 154, 161, 167, 208, 245, 253, 331, 457, 493, 509, 619, 697, 721, 798
  - zinc ... 18a, 55, 57, 77, 167, 208, 253, 331, 457, 493, 509, 697, 721, 798
- Mineral waters, summary ... 21a, 37a
- Minnesota, cooperation ... 25a
  - iron ore ... 560–561, 567, 568, 585
    - reserves ... 578
  - manganese ores ... 669–671, 684
  - manganiferous ores ... 670–671
  - pig iron ... 586–587, 588
  - value of mineral products ... 46a, 59a
- Mississippi, value of mineral products ... 46a, 60a
- Missouri, cooperation ... 25a
  - cobalt ... 901
  - copper ... 77, 101, 725, 738, 742
  - gold ... 605
  - iron ore ... 560–561, 567, 568, 585
  - lead ... 77, 104, 883, 888
  - manganese ore ... 684
  - nickel ... 901, 920
  - pig iron ... 586–587, 588
  - silver ... 77, 101, 605, 619, 625
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop ... 100–118
  - tungsten ... 932
    - mills ... 945
  - value of mineral products ... 46a, 60a
  - zinc ... 77, 104, 862–863, 864, 867
- Molybdenum, by Frank L. Hess ... 907–915
  - concentration and reduction ... 915
  - disposition ... 914
  - industry by States ... 908–914

Page.
Molybdenum, imports ... 599
  introduction ... 907
  minerals and ores ... 907
  prices ... 908
  production ... 908
  uses ... 914–915
Monazite and zircon, summary ... 21a, 22a, 37a
Montana, arsenic ... 24
  copper ... 331, 725, 738–740, 742, 763–766
  gold ... 331, 605, 619, 625, 634, 637, 642, 646
  gold, silver, copper, lead, and zinc (mines report), by V. C. Heikes ... 18a, 331–366
  iron ore ... 560–561, 568
  lead ... 331, 883, 888
  manganese ore ... 670–671, 684
  molybdenum ... 913
  quicksilver ... 385, 402, 415
  silver ... 331, 605, 619, 625, 639, 642, 646
  tungsten ... 932, 943
    mills ... 945
  value of mineral products ... 46a, 61a
  zinc ... 331, 862–863, 864
Morocco, iron ore ... 583
Mottled pig iron ... 591

N.

Natal, silver ... 615
Natural gas, summary ... 21a
Nebraska, value of mineral products ... 46a, 61a
Netherlands, copper, exports to ... 780
  manganese ore, imports from ... 673
  pig iron, exports to ... 595
    imports from ... 594
  platinum ... 15
  quicksilver, exports to ... 382
Nevada, antimony ... 657
  copper ... 253, 725, 738–740, 742, 766–769
  gold ... 253, 605, 619, 626, 634, 637, 642, 646
  gold, silver, copper, lead, and zinc (mines report), by V. C. Heikes ... 18a, 253–298
  iron ore ... 560–561, 568
  lead ... 253, 883, 888
  manganese ore ... 669–671, 684
  manganiferous ore ... 675
  molybdenum ... 913
  platinum ... 20
  quicksilver ... 370, 372, 373, 385, 401, 415–418
  silver ... 253, 605, 619, 626, 639, 642, 646
  tin ... 64–65
  tungsten ore ... 932–933, 943–944
    mills ... 946
  value of mineral products ... 46a, 62a
  vanadium ore ... 956
  zinc ... 253, 862–863, 864
New Caledonia, chromic iron ore ... 42
  nickel ... 917, 920, 921, 923
  quicksilver ... 399
Newfoundland, antimony ... 659
  copper ... 726
  iron ore ... 583
    imports from ... 579
  pig iron, imports from ... 594
  quicksilver, exports to ... 382
New Hampshire, gold, silver, copper, lead, and zinc in Eastern States (mines report) ... 56, 58
New Hampshire, lead ... 57, 58, 883, 888
  silver ... 56, 605, 619, 625, 639
  tungsten ore ... 944
  value of mineral products ... 46a, 62a
  zinc ... 57, 58, 862–863
New Jersey, antimony, smelters ... 658
  cooperation ... 25a
  copper ... 725, 738
  ferroalloys ... 598
  gold, silver, copper, lead, and zinc (mines report) ... 57, 59
  iron ore ... 560–561; 567, 568, 585
    district ... 562
  pig iron ... 386–387, 588
  steel ... 600
  value of mineral products ... 46a, 63a
  zinc ... 57, 59, 862–863, 864, 867
    residuum ... 570
New Mexico, copper ... 697, 725, 738–740, 742, 769–770
  gold ... 605, 619, 626, 634, 642, 646, 697
  gold, silver, copper, lead, and zinc (mines report), by C. W. Henderson ... 18a, 697–720
  iron ore ... 560–561, 567, 568, 585
  lead ... 697, 883, 888
  manganese ore ... 670–671, 685
  manganiferous ore ... 674
  quicksilver ... 385
  silver ... 605, 619, 626, 639, 642, 646, 697
  tungsten ... 932, 944
  value of mineral products ... 46a, 63a
  zinc ... 697, 862–863, 864
New South Wales, platinum ... 13, 14
New York, aluminum ... 7
  cooperation ... 25a
  ferroalloys ... 598
  gold, silver, copper, lead, and zinc (mines report) ... 57, 59
  iron ore ... 560–561, 567, 568, 585
    district ... 562
    titaniferous ... 929
  pig iron ... 586–587, 588
  steel ... 600
  value of mineral products ... 46a, 64a
  zinc ... 57, 59, 862–863, 864, 867
New Zealand, manganese ore ... 690
  pig iron, exports to ... 595
  quicksilver ... 399
    exports to ... 382
Nicaragua, quicksilver, exports to ... 382
Nickel, by Frank L. Hess ... 917–927
  Canada ... 917–919, 921
  consumption and control ... 921–922
  exports ... 36a, 923
  geographic distribution ... 920–921
  imports ... 35a, 922–923
  modes of occurrence ... 920
  prices ... 922
  production ... 917
  publications ... 923–927
  recovery ... 920
  secondary ... 312, 329–330
  summary ... 19a, 35a, 36a
Nickel, world's production ... 921
Nigeria, tin ... 69

Page.

- North Carolina, aluminum 7
  - chromite 38
  - cooperation 25a
  - copper 56, 59, 725, 738, 742
  - gold 56, 59, 605, 619, 627, 634
  - gold, silver, copper, lead, and zinc (mines report) 56, 59-60
  - iron ore 560-561, 567, 568, 585
  - lead 57, 59, 883, 888
  - manganese ore 671
  - silver 56, 59, 605, 619, 639
  - tin 65
  - value of mineral products 46a, 65a
- North Dakota, value of mineral products 46a, 65a
- Norway, copper 726, 793
  - gold 613
  - iron ore 583
    - imports from 579
  - nickel 921
  - pig iron, exports to 595
    - imports from 594
  - quicksilver, exports to 382
  - rutile 930
  - silver 615

O.

- Ocher, summary 37a
- Ohio, ferroalloys 598
  - iron ore 560, 567, 568
  - pig iron 586-587, 588
  - steel 600
  - value of mineral products 46a, 66a
- Oilstones and whetstones, summary 21a, 37a
- Oklahoma, lead 77, 118, 883, 888
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop 118-125
  - silver 606, 625
  - value of mineral products 46a, 67a
  - zinc 77, 118, 856, 862-863, 864, 867
- Ontario, cobalt 905
  - nickel 917, 920, 923
- Open-hearth steel 600, 601
- Orange mineral 886, 894
- Oregon, chromite 38
  - cooperation 25a
  - copper 245, 725, 738-740, 743, 775
  - ferroalloys 598
  - gold 245, 605, 619, 626, 634, 642, 646
  - gold, silver, copper, lead, and zinc (mines report), by C. G. Yale 18a, 243-252
  - lead 245, 883
  - molybdenum 913
  - platinum 13, 17-19, 21
  - quicksilver 370, 372, 373, 385, 400, 418-421
  - silver 245, 605, 619, 627, 639, 642, 646
  - tungsten 932, 944
  - value of mineral products 46a, 67a
- Osmium, imports 35a, 15
  - summary 19a, 35a
  - uses 12
- Osmiridium, imports 35a, 15
  - production 14
  - summary 19a, 37a
- Ozokerite, summary 37a

P. Page.

- Palladium 12, 14, 15, 16
  - (*See* Platinum and allied metals.)
  - summary 19a, 35a
- Panama, manganese ore 674
  - imports from 673
  - pig iron, exports to 595
  - platinum 15
  - quicksilver, exports to 382
  - tungsten ore, imports 934
- Paraffin, summary 37a, 38a
- Paris green 25
- Peat, summary 21a, 37a
- Pennsylvania, cooperation 25a
  - copper 56, 60, 725, 738, 743
  - ferroalloys 598
  - gold 625
  - gold, silver, copper, lead, and zinc (mines report) 56, 60
  - iron ore 560-561, 567, 568, 585
  - lead 883
  - manganese ore 670
  - pig iron 586-587, 588
  - silver 605, 619, 625
  - steel 600
  - value of mineral products 46a, 68a
  - zinc 856, 867
- Peru, antimony 659
  - copper 726, 792
    - imports from 779
  - gold 613
  - pig iron, exports to 595
  - quicksilver, exports to 382, 403
  - silver 615
  - tungsten 934
  - vanadium 956
- Petroleum, summary 21a, 37a, 38a
- Philippine Islands, gold and silver 605, 619, 629
  - iron ore 583
  - quicksilver, exports to 382
- Phosphate rock, summary 21a, 37a, 38a
- Pig iron and steel 586-603
  - (*See also* Iron ore, pig iron, and steel.)
  - blast furnaces 590-591
  - curve showing prices of basic pig iron 589
  - curve showing production of coke and anthracite pig iron, by months 592
  - exports 36a, 594-595
  - ferroalloys, shipments and value 596-598
    - imports 35a, 599
    - manufacture of, by States 596
    - (*See also* Ferroalloys.)
  - imports 594
  - percentage of pig iron to iron ore 570
  - prices 587-590
  - production, by States 586-587
    - according to fuel used 593
    - by grades 591
    - 1889-1917 570
    - monthly 591
    - total 593
  - shipments, by States 587
    - increase or decrease 587
    - percentage of change 587
  - value 587
  - world's production 595

Page.

- Pig iron and steel, steel, production 599–601
  - steel, Bessemer ingots and castings 600, 601
    - crucible 601
    - electric 600–601
    - exports 603
    - foreign trade 602–603
    - imports 602
    - open-hearth ingots and castings 600, 601
      - total 601
  - summary 19a, 35a, 36a
- Pigments, lead 37a, 38a, 885–886
- Platinum and allied metals, by J. M. Hill 11–21
  - allied metals 11–12
  - imports 35a, 36a, 15
  - market 16–17
  - notes on platinum deposits 17–21
    - Alaska 13, 19
    - Borneo 13, 14, 15
    - California 13, 17–19
    - Canada 13, 14, 15, 20
    - Colombia 13, 14, 15, 17, 20
  - general conditions in United States 17–19
    - mining 18–19
    - Nevada 20
    - New South Wales 13, 14
    - Oregon 13, 17–19, 20
    - Russia 13, 14, 17, 21
    - Tasmania 13, 14
    - Washington 13, 20
    - Wyoming 20
  - prices 16, 17
  - production, domestic, crude 13
    - refined 14
    - secondary 14
    - total 13
  - substitute for 904
    - composition 904
  - summary 19a, 35a, 36a
  - supply 12–13
  - uses 11–12
  - world's production 12–13, 14
- Port Colborne, Canada, receipts of iron ore 573
- Porto Rico, gold and silver 605, 619
  - manganese ore 674, 690
  - manganese ore, imports from 623
- Portugal, antimony 659
  - copper 792
  - gold 613
  - iron ore 583
  - manganese ore, imports from 673
  - quicksilver 395
  - silver 615
  - tin 69
  - tungsten 934
- Portuguese Africa, antimony 659
  - chromic iron ore 42
  - quicksilver, exports to 382
  - silver 615
- Potassium salts, summary 21a, 37a, 38a
- Prefatory note, by H. D. McCaskey 77a–79a
- Prices, aluminum 6
    - salts 8, 9
  - antimony 654, 661
  - arsenic 26–27
  - bauxite 3

Page.

- Prices, bismuth 29
  - cadmium 50, 52–53
  - chromite 39
    - salts 42
  - cobalt 904
  - copper 724, 783–784
  - ferroalloys 597, 598
  - ferromanganese 598, 681
  - iridium 16
  - iridosmine 16
  - iron ore 567–568, 575–576
    - Lake Superior 575–576
  - lead 882, 896, 897
  - magnesium 148
  - manganese ore 676–678, 681
  - manganiferous ores 678
  - manganiferous zinc residuum 678
  - molybdenum 908
  - nickel 922
  - palladium 16
  - pig iron 587–590
  - platinum 16, 17
  - quicksilver 371, 377, 379–381
  - radium 957
  - selenium 33
  - silver 607
    - 1850–1917 .... 79a
  - spiegeleisen 598
  - tellurium 35
  - tin 67–68
  - tungsten 934, 935
  - uranium 957
  - vanadium 957
  - zinc 878–879
    - 1850–1917 .... 79a
    - dust 878
- Principal iron-ore mines 564–567
- Pumice, summary 37a
- Pyrite, summary 21a, 37a

Q.

- Quartz, summary 32a
- Queensland, iron ore 583
- Quicksilver, by F. L. Ransome 367–455
  - bibliography of quicksilver in North America, compiled by Isabel P. Evans 425–455
    - index to bibliography 426–432
    - select bibliography 432–455
    - serials examined 425–426
  - consumption of quicksilver in gold and silver mining 385–386, 648–651
  - costs 376–378
  - general geographic and geologic relations of quicksilver deposits 386–389
    - in the world as a whole 386–387
      - map showing location of productive quicksilver deposits 386
    - in the United States 387–389
      - map showing location of known deposits of the United States 388
  - imports and exports 381–382
  - introduction 367–368
  - methods of treatment of ore 373–376

Quicksilver—Continued. Page.
- mineralogy of quicksilver ores 390-393
  - general character of ores 390
  - minerals containing mercury 390-393
  - tenor 393
- prices 371, 377, 379-381
  - diagram showing variations of monthly average market, quotations at San Francisco, 1913-1917 377
  - diagram showing prices in London, New York, and San Francisco in 1917 380
- production 369-372
  - domestic production 369-371
    - by States 370
    - diagram showing quantity and value of quicksilver produced in the United States, 1850-1917 369
- quantity and tenor of ore treated 372-373
- quicksilver-mining industry by States 404-424
  - Alaska 404
  - Arizona 404-405
  - California 405-414
  - Idaho 414-415
  - Montana 415
  - Nevada 415-418
  - Oregon 418-421
  - Texas 421-424
  - Utah 424
  - Washington 424
- review of quicksilver deposits of the world 394-404
  - Africa 399
  - Asia 397-398
    - Turkey 397-398
    - Russia 397
    - China 398
    - Japan 398
    - East Indies 398
  - Europe 394-397
    - Spain 394-395
    - Portugal 395
    - France 395
    - Germany 395
    - Austria-Hungary 395-396
    - Italy 396-397
    - Russia 397
    - Serbia 397
  - North America 399-403
    - Alaska 399-400
    - Canada 400
    - Washington 400
    - Oregon 400
    - California 400-401
    - Nevada 401
    - Idaho 401
    - Montana 402
    - Utah 402
    - Arizona 402
    - Texas 402
    - Mexico 402-403
    - Central America 403
  - Oceania 399
    - Australia 399
    - New Zealand 399
    - New Caledonia 399
  - South America 403-404

Quicksilver—Continued. Page.
- statistical summary 367
- summary 19a, 35a, 36a
- uses 383-385
- value 370-371
- world's production 371-372

R.

Radium, uranium, and vanadium, by Frank L. Hess 955-959
- exports 957
- imports 35a, 957
- prices 957
- production 955-956
- publications 958-959
- summary 19a, 35a, 36a
- uses, demand, and trade 956-957

Ransome, F. L., paper on quicksilver 367-455
Red lead 21a, 37a, 38a, 886, 894
Rhode Island, value of mineral products 46a, 69a
Rhodesia, copper 726
- silver 615

Rhodium, imports 35a
- summary 19a, 35a
- uses 12

Rottenstone, summary 37a
Russia, copper 726, 794
- exports to 786
- gold 613
- iron ore 583
- manganese ore 674, 687
  - imports from 666, 673
- pig iron 595
  - exports to 595
- platinum 13, 14, 17, 21
- quicksilver 372, 397, 398
  - exports to 382
- silver 615

Ruthenium, summary 35a
Rutile 929-930
- summary 35a, 73a
- (*See also* Titanium.)

S.

Salt, summary 21a, 37a, 38a
Salvador, quicksilver, exports to 382
Sand and gravel, summary 21a, 37a, 38a
Sand-lime brick, summary 32a
Sandusky, Ohio, stocks of iron ore 575
Santo Domingo (Dominican Republic), quicksilver exports to 382
Scotland, aluminum 7
Secondary metals, by J. P. Dunlop 299-330
- aluminum 6-7, 312, 327-329
- antimony 312, 320
- brass, remelted 312
- copper 312-317, 730
- introduction 299-312
  - classification for old metals 307-309
  - industry in 1917 309-311
  - metals recovered 312
  - recovery of waste material 299-305
    - Army reclamation division 300
    - economics by Navy Department 301
    - need of conserving waste 299
    - scrap-iron dealers 302
    - sources of information 304
  - scope of report 299
  - warring on waste, by W. C. Hirsch 305-307

Page.

- Secondary metals, lead 312,317-319
  - nickel 312,329-330
  - platinum 14
  - recovery of metals 312
  - summary 19a
  - tin 312,320-327
  - value 312
  - zinc 312,319-320
- Selenium, by J. B. Umpleby 33
  - prices 33
  - production 33
  - summary 19a,37a
  - uses 33
- Serbia, copper 726,793
  - gold 613
  - quicksilver 397
  - silver 615
- Siam, gold 613
  - tin 69
  - tungsten 934
- Siebenthal, C. E., paper on cadmium 49-53
  - on lead 881-897
  - on zinc 855-879
- Siberia, gold 613
- Sienna and umber, summary 37a
- Silica, summary 32a
- Silver 30a
  - (*See also* Gold and silver.)
    - mine production 18a, 55, 77, 132, 154, 161, 167, 208, 245, 253, 331, 457, 493, 509, 619, 697, 721, 798
  - production 605, 619, 645-648
  - summary 30a
- Silver, copper, lead, and zinc in the Central States (mines reports), by B. S. Butler and J. P. Dunlop 73-130
  - introduction, by J. P. Dunlop 73-74
  - lead and zinc, production, by regions 77-79
  - production 75-77
  - publications 129-130
  - summary of production, by States 77
  - tenor of copper, lead, and zinc ores 74-75
  - Arkansas, by J. P. Dunlop 78-82
  - Illinois, by J. P. Dunlop 82-86
  - Iowa, by J. P. Dunlop 86-87
  - Kansas, by J. P. Dunlop 87-90
  - Kentucky, by J. P. Dunlop 90-92
  - Michigan, by B. S. Butler 92-100
  - Missouri, by J. P. Dunlop 100-118
  - Oklahoma, by J. P. Dunlop 118-125
  - Wisconsin, by J. P. Dunlop 125-129
- Singkep, tin 69
- Slate, summary 21a,37a,39a
- Smith, George Otis, paper on economic limits to domestic independence in minerals 1a-6a
- Soapstone, summary 22a
- Sodium nitrate, summary 37a
- Sodium salts, summary 22a
- South Africa, chromic iron ore 42
  - copper 726
  - quicksilver, exports to 382
  - tin 69
  - tungsten 934
- South America, gold 613
  - lead 883

Page.

- South America, lead, imports from 893
  - manganese ore 674,687
  - quicksilver 403-404
  - silver 615
- South Australia, iron ore 583
- South Carolina, copper 725,738
  - gold 56,60,605,619,627,634
  - gold, silver, copper, lead, and zinc (mines report) 56,60
  - manganese ore 671,685
  - silver 56,60,619,639
  - tin 65
  - value of mineral products 46a,69a
- South Chicago, Ill., iron-ore receipts 574
  - copper 154,738,743
- South Dakota, gold 154,605,619,627,634,642,646
  - gold, silver, copper, and lead (mines report), by C. W. Henderson 18a,153-160
  - lead 154,883,888
  - quicksilver 385
  - rutile 929
  - silver 154,605,619,627,639,642,646
  - tin 65
  - tungsten ore 932,944
    - mills 946
  - value of mineral products 46a,70a
- Spain, copper 726,792
    - imports from 779
  - gold 613
  - iron ore 583
    - imports from 579
  - manganese ore 674
  - molybdenum in ores 907
  - pig iron 595
    - exports to 595
  - quicksilver 372,394-395
  - silver 615
  - tin 69
  - zinc 873
- Spiegeleisen, imports 35a,599
  - plants making spiegeleisen 679
  - prices 598
  - production 591,597
  - summary 35a
  - (*See also* Manganese ore.)
- Steel ....
  - (*See* Pig iron and steel.)
- Stellite 899-904
- Stone, Ralph W., paper on magnesium 147-151
- Stone, summary 22a,37a,39a
- Straits Settlements, tin 66
- Strontium, summary 22a,37a
- Sudbury, Canada, nickel 917-919,921-923
- Sublimed blue and white lead 31a,885-886
- Sulphur, summary 22a,37a,39a
- Sulphuric acid from smelters, summary 22a
- Sumatra, platinum 14
- Summary of mineral production, by M. B. Clark 27a-76a
  - (*See also* Mineral production of the United States in 1917—a summary.)
- Superior, shipments of iron ore 573
- Swaziland, tin 69
- Sweden 726
  - gold 613
  - iron ore 583
    - imports from 579

Page.
Sweden, manganese ore.......... 674
  pig iron.......... 595
    exports to.......... 595
    imports from.......... 594
  quicksilver, exports to.......... 382
  silver.......... 615
  zinc.......... 595
Switzerland, pig iron, exports to.......... 595
  imports from.......... 594

T.

Talc and soapstone, summary.......... 22a, 37a
Tantalum, summary.......... 35a
Tariff, lead.......... 891-892
  nickel.......... 922
  quicksilver.......... 381
  zinc.......... 869
Tasmania, copper, imports from.......... 779
  nickel, imports from.......... 923
  platinum.......... 13, 14
Tellurium, by J. B. Umpleby.......... 35
  prices.......... 35
  production.......... 35
  summary.......... 19a
Tennessee, aluminum.......... 7
  bauxite.......... 1, 3-5
  copper.......... 56, 61, 725, 738, 743, 770, 772
  ferroalloys.......... 598
  gold.......... 56, 61, 605, 619, 627, 634, 642, 646
  gold, silver, copper, lead, and zinc (mines report).......... 56, 60-61
  iron ore.......... 560-561, 567, 568, 585
  lead.......... 57, 61, 883, 888
  manganese ore.......... 669-671, 685
  pig iron.......... 586-587, 588
  silver.......... 56, 61, 605, 619, 639, 642, 646
  value of mineral products.......... 46a, 70a
  zinc.......... 57, 61, 862-863, 864
Texas, copper.......... 721, 725, 738, 743
  gold.......... 605, 619, 628, 634, 642, 646, 721
  gold, silver, copper, lead, and zinc (mines report), by C. W. Henderson. 18a, 721-722
  lead.......... 721, 883, 888
  manganese ore.......... 669-671, 685
  quicksilver.......... 370, 372, 373, 378, 402, 421-424
  silver.......... 605, 619, 628, 639, 642, 646, 721
  tin.......... 65
  value of mineral products.......... 46a, 71a
  zinc.......... 721, 862-863
Thorium oxide, summary.......... 37a
Tin, by Adolph Knopf.......... 63-72
  Alaska.......... 63-64
  California.......... 63
  curve showing average yearly prices.......... 68
  exports.......... 36a
  general statement.......... 63
  imports.......... 35a, 66-67
  Nevada.......... 64-65
  North Carolina.......... 65
  prices.......... 67-68
  production.......... 63-65
  publications.......... 71
  secondary.......... 312, 320-327
  smelting.......... 65-66
  South Carolina.......... 65
  South Dakota.......... 65

Page.
Tin, summary.......... 19a, 35a, 36a
  Texas.......... 65
  world's output.......... 68-71
  map of, in 1916.......... 70
Titanium, by Frank L. Hess.......... 929-930
  imports.......... 35a, 599
  occurrence and uses.......... 929-935
  production.......... 929
  recent patents.......... 930
  summary (rutile).......... 30a, 35a, 73a
Toledo, Ohio, receipts of iron ore.......... 573
  stocks of iron ore.......... 575
Transvaal silver.......... 615
Tripoli, summary.......... 37a
Tungsten, by Frank L. Hess.......... 931-954
  consumption.......... 933
  exports.......... 36a, 933
  general conditions.......... 931
  imports.......... 36a, 599, 933
    by countries.......... 934
  tungsten mills.......... 944-947
  mining, by States.......... 935-944
  ore.......... 35a
  prices.......... 934
  production.......... 931-933
    by States.......... 932-933
  publications.......... 947-954
  summary.......... 19a, 35a, 36a
  supply.......... 933
  world's production.......... 947
Tunis, iron ore.......... 583
  manganese ores.......... 674, 686
Turkey, chromic iron ore.......... 42
  copper.......... 726
  gold.......... 613
  quicksilver.......... 397
  silver.......... 615
Two Harbors, shipments of iron ore.......... 573
Type metal, imports.......... 35a, 660, 893

U.

Umber, summary.......... 37a
Umpleby, Joseph B., paper on arsenic, bismuth, selenium, and tellurium.......... 23-35
Union of South Africa, manganese ore.......... 674, 690
United Kingdom, aluminum.......... 7
  antimony.......... 659
  bauxite.......... 3
  cadmium.......... 50
  chromic iron ore.......... 42
  copper, exports to.......... 780
    imports from.......... 779
  iron ore.......... 583
    exports to.......... 580
    imports from.......... 579
  lead, imports from.......... 893
  manganese ore.......... 674
    imports from.......... 673
  pig iron.......... 595
    exports to.......... 595
    imports from.......... 594
  quicksilver, exports to.......... 382
Uranium and vanadium.......... 955-959
  (*See also* Radium, uranium, and vanadium.)
Uranium and vanadium, ore.......... 955, 956
  summary.......... 19a, 35a

Page.

- Uruguay, bismuth.... 31
  - gold.... 613
  - silver.... 615
- Utah, antimony.... 658
  - copper.... 167, 725, 738–740, 743, 772–775
  - gold.... 167, 605, 619, 628, 634, 637, 642, 646
  - gold, silver, copper, lead, and zinc (mines report), by V. C. Heikes.... 19a, 167–202
  - iron ore.... 560–561, 568
  - lead.... 167, 883, 888
  - manganese ore.... 669–671, 685
  - manganiferous silver ore.... 675
  - molybdenum.... 907, 913–914
  - quicksilver.... 385, 424
  - silver.... 167, 605, 619, 628, 639, 642, 646
  - tungsten.... 932–933, 944
    - mills.... 946
  - uranium.... 955
  - value of mineral products.... 47a, 72a
  - vanadium.... 955, 956
  - zinc.... 167, 862–863, 864

V.

- Value of mineral products, by substances, 1916-17.... 30a–32a
  - total, 1880-1917.... 33a
- Vanadium.... 955–959
  - (*See also* Radium, uranium, and vanadium.)
  - ore.... 955–956
  - summary.... 19a, 36a
- Venetian red, summary.... 37a
- Venezuela, copper.... 726
  - gold.... 613
  - iron ore.... 583
    - imports from.... 579
  - platinum.... 15
  - quicksilver, exports to.... 382
  - silver.... 615
- Vermilion range, iron ore.... 571–572, 578
- Vermont, copper.... 56, 61, 725, 738, 743, 775
  - gold.... 605, 619, 625
  - gold, silver, copper, lead, and zinc (mines report).... 56, 61
  - silver.... 56, 605, 619, 625, 639, 642, 646
  - value of mineral products.... 47a, 73a
- Virginia, arsenic.... 23, 24
  - cooperation.... 25a
  - copper.... 56, 62, 725, 738, 743, 775
  - ferroalloys.... 598
  - gold.... 56, 62, 605, 619, 627, 634, 642, 646
  - gold, silver, copper, lead, and zinc (mines report).... 56, 61–62
  - iron ore.... 560–561, 567, 568, 585
  - lead.... 57, 62, 883, 888
  - manganese ore.... 669–671, 685
  - manganiferous ore.... 670–671
  - pig iron.... 586–587, 588
  - silver.... 56, 62, 605, 619, 639, 642, 646
  - titanium (rutile).... 73a, 929, 930
  - value of mineral products.... 47a, 73a
  - zinc.... 57, 62, 862–863, 864

W.

- Washington, arsenic.... 23, 24
  - chromite.... 38
  - cooperation.... 25a
  - copper.... 493, 725, 738–740, 743, 775

Page.

- Washington, ferroalloys.... 598
  - gold.... 493, 605, 619, 629, 634, 637, 642, 646
  - gold, silver, copper, lead, and zinc (mines report), by C. N. Gerry.... 19a, 493–507
  - lead.... 493, 883, 888
  - magnesium.... 151
  - manganese ore.... 669–671
  - molybdenum.... 914
  - pig iron.... 586–587, 588
  - platinum.... 13, 20
  - quicksilver.... 385, 400, 424
  - silver.... 493, 605, 619, 629
  - tungsten ore.... 932, 944
    - mills.... 946
  - value of mineral products.... 47a, 74a
  - zinc.... 493, 862–863
- West Virginia, iron ore.... 560–561, 568
  - pig iron.... 586–587, 588
  - value of mineral products.... 47a, 75a
  - zinc smelters.... 867
- Whetstones, summary.... 37a
- White lead.... 37a, 886, 894, 895
- Wisconsin, cooperation.... 25a
  - iron ore.... 560–561, 567, 568
  - lead.... 77, 126, 883, 888
  - manganiferous iron ore.... 669–671
  - pig iron.... 586–587, 588
  - silver, copper, lead, and zinc (mines report), by J. P. Dunlop.... 125–129
  - value of mineral products.... 47a, 75a
  - zinc.... 77, 126, 862–863, 864
- World's production, bauxite.... 3
  - copper.... 725–726
  - gold.... 611–614
  - iron ore.... 583
  - lead.... 891
  - manganese ore.... 673–674
  - nickel.... 921
  - pig iron.... 595
  - platinum.... 13, 14
  - quicksilver.... 371–372
  - silver.... 614–615
  - tin.... 68–71
  - tungsten.... 947
  - zinc.... 868
- Wyoming, copper.... 161, 725, 738–740, 743, 775
  - gold.... 161, 605, 619, 629, 634, 642, 646
  - gold, silver, and copper (mines report), by C. W. Henderson.... 19a, 161–165
  - iron ore.... 560–561, 568
  - lead.... 883
  - manganese ore.... 671, 686
  - platinum.... 20
  - silver.... 161, 605, 619, 629, 639, 642, 646
  - value of mineral products.... 47a, 76a

Y.

- Yale, Charles G., paper on gold, silver, copper, lead, and zinc in California (mines report).... 203–239
  - Oregon (mines report).... 241–252

Z.

- Zinc, by C. E. Siebenthal.... 855–879
  - brass, exports.... 875
    - imports, old.... 871
      - remelted.... 312

Page.
Zinc, comparison of smelter and mine reports 860–862
    consumption 855, 876–877
        in United States 876–877
    content of pigments 859
    dross, exports of 36a, 874
    dust 858, 859, 870, 871, 878
    exports, domestic 36a, 873–875
        foreign 875–876
    imports 35a, 869–873
    introduction 855
    lithopone 859
        imports 871
    mine and smelter totals 860–862
    mine production 18a, 55, 77, 167, 208, 253, 331, 457, 493, 509, 697, 721, 798, 862–864
    mined in 1917, by States and ores 863
    ore 863–864, 870, 872–873, 874
        imports from Canada and Mexico 872
    oxide 859
        exports 874
        leaded zinc 859
        zinc-lead 859
        imports 37a, 871
        summary 37a
    pigments 859
    prices 878–879
        at St. Louis in 1914–1917 .... 878, 879
        curves 878
        dust 878

Page.
Zinc, prices, 1850–1917 .... 79a
    production 855–864
        annual, 1873–1917 856
        by districts 864
        by location of smelter 856
        by States 856, 862–863
        electrolytic 856, 865
    reduction plants 865–868
        electrolytic plants 865
        smelters, list of 866–868
        smelting capacity and changes 868
    remaining in warehouse 870
    residues 883
    residuum 570, 669, 678
    rolled zinc 857–858
    secondary zinc 312, 319–320, 859–860
    smelter and mine totals 860–862
    summary 19a, 35a, 36a, 855
    tariff 869
    trade conditions 868–879
    value 855, 879
    warehouse transactions 869–870
    world's production 868
Zinc-lead 859, 886
    ore 863
Zinc oxide 859, 886
    (*See also* Zinc.)
    summary 37a
Zinc residuum, manganiferous 570, 669, 678
Zircon, summary 22a

18

RX 001 878 187